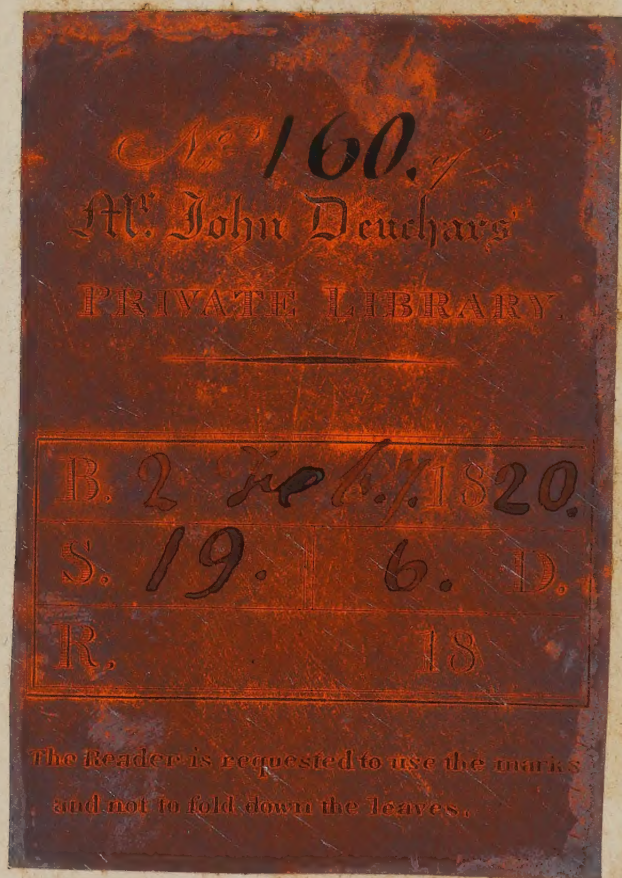




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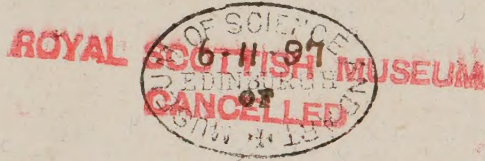
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GENERAL SYSTEM

OF

CHEMICAL KNOWLEDGE,

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GENERAL SYSTEM

ROYAL SCOTISH MUSEUM



As. 1.

CHEMICAL KNOWLEDGE;

AND ITS

APPLICATION

TO THE

PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

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A
S Y S T E M
OF
CHEMICAL KNOWLEDGE.

SEVENTH SECTION.

Of the Vegetable Organic Compounds.

INTRODUCTION TO THIS SECTION.

1. **I** HAVE hitherto treated of substances, all which belong, by reason of their simplicity or their little complicated composition, to the bodies which naturalists place in what they term the *mineral kingdom*, and which, as they compose the solid mass of the globe, deserve more accurately the name of fossils. The substances whose history I am about to write, and which constitute the section I now commence, are of a very different nature: much more complicated than the preceding, the vegetable substances not only form a very distinct order of bodies, but they also require to be examined, and treated according to a very different method. The course of the science ought here to differ as

well as that of nature ; and instead of dividing this section, like the preceding ones, into articles placed successively, one after the other, and placed as the necessary and continued series of truths connected immediately with each other, the facts and the phenomena are here too complicated, and hitherto too little as yet approached to each other, and too little dependant, for it to be possible that I should present them, like those of the preceding sections, in a continued and uninterrupted series of articles.

2. I am therefore obliged to divide all that I have to say relative to the vegetable compounds into six orders of facts, which comprehend all the knowledge hitherto acquired, and even the ideas of what is still to be acquired, respecting the nature, the formation, the difference, and the alterations of these compounds. For it is here to be remarked, that vegetable bodies are divided and separated from the mineral substances by a great difference with relation to the chemical parts which compose them. Organic compounds in general, and those which belong to the vegetables in particular, are still much less known than the mineral substances ; and though, as we shall soon see, modern chemistry has singularly advanced the vegetable analysis, it has rather, as yet, acquired hopes and produced writings, than collected general results. The great point in the study of this beautiful department of science is, to familiarize ourselves with the well-established

blished and positive notions already in our possession,—to acquire at the same time a clear understanding of what still remains defective,—to comprehend well the means of acquiring what it wants,—to appreciate rightly the truth of the speculative views to which it has raised itself,—and to become able, by means of those valuable instruments which we begin to know how to employ, to advance this very interesting branch of natural philosophy.

3. The six orders of facts into which I divide, and under which I comprehend all that belongs at present to vegetable Chemistry, are reducible under the following heads :

The first relates to the structure of vegetables, and the difference of this structure from the texture or the masses of mineral substances. It would be impossible to form a conception of their chemical properties, if we had not an exact though precise notion of their organization, or the first cause of the differences which distinguish them from inorganic substances.

In the second order of facts, I include what relates to the vegetable nature or composition in general: this is a necessary consequence of their organization, which admits of a kind of combination very different from that of the minerals; and it is necessary first to know in what this difference consists.

To the third order belongs the kind of action which the principal substances already examined exert upon vegetables; that is to say, the che-

mical characters which they present, by means of which we discover their nature, and determine their composition.

The fourth order of facts comprehends the examination of all the substances which are extracted from vegetables, which really constitute them, and which on that account are called the *principles* or *immediate materials* of vegetables. This is the longest, and requires the most details, because it is the most abundant in facts, upon which the most labour has been bestowed, and has hitherto solely constituted the vegetable analysis.

In the fifth order I rank the exposition and study of the different natural alterations to which vegetables are liable, and which, being dependant upon their composition, are at the same time very proper for acquainting us with its nature.

Lastly, to the sixth order of facts I refer what I term the phenomena of vegetable life, or the application of all the facts preliminarily explained in the preceding orders, to the vegetable physics. This last, which is the complement of all the rest, the object to which they manifestly lead, is one of the most beautiful results of modern chemistry.

First Order of Facts relative to the Vegetable Compounds.

Concerning the Structure of Vegetables, and the Physical Differences which distinguish them from inorganic Bodies.

ARTICLE I.

— *Of the external or apparent Structure of Vegetables.*

1. THE first observations which man, placed upon this earth, could make upon the productions of nature around him, must have showed him that vegetables differed in a remarkable manner from the substances which form the mass of the globe in their appearance, stature, aspect, and all the properties which quickly characterized them to his eyes. When he wished to account for the difference that had struck him, he could not fail to remark in particular the variety and the dissimilarity of their parts, and the diversity of form in the different points of their surface; whilst the stone, the pebble, the mineral and the fossil, of whatever nature they might be, presented to him a perfectly uniform whole, a mass homogeneous throughout all its continuity.

2. When we wish to define a vegetable, we are obliged to consider it as a compound of different dissimilar parts, which are designated by the names of *root, stalk, leaves, flowers, fruits, and seeds*. The vegetable which presents all these

these parts, developed successively and at different periods of its life, is called a *perfect vegetable*. Those in which some of these parts are wanting are termed *imperfect*. There are some plants which seem to be nothing else than roots, such as the truffles, and others which want them, as the lichens, &c. There are some which have no leaves, and seem to consist merely of stalks and branches, whilst others have only leaves without stalks: some present very distinct and easily recognizable flowers; others present no organs that can be considered as flowers, though there are, in fact, no vegetables that are really destitute of them. In the one, we easily observe the fruits and the seeds; in the others we find no parts that resemble them. However, the number of vegetables which contain all these parts is so considerable, and they appear to be so constant, and so deeply connected with the nature of vegetable, that we are induced to believe that even those which seem to be totally deprived of them, present, when attentively examined, parts which might be considered as real flowers or fruits necessary to the re-production and the propagation of the species.

2. The root, which is most frequently buried in the ground, sometimes immersed in the water, or penetrating the texture of various other vegetables, supports the whole plant; it takes up and conducts into the vegetable a large portion of its nourishment, by the fibrils which
are

are termed capillary, and which may be considered as absorbent vessels, as mouths destined to suck in the juices of the earth and of the manures. Botanists distinguish roots according to their form, texture, and situation, into the tuberous, the bulbous, the fibrose, the contorted, the repent, the horizontal, the oblique, the rounded, the irregular, the conical, the cylindrical, the fusiform, the articulated, the palmated, the fleshy, the woody, &c. &c. These differences have even been frequently employed by them to serve as characters of different species.

4. The stem which proceeds immediately from the root, with which it appears to be continuous, though it is of a very different structure, is the general support of all the parts: it is termed *trunk*, when it is bulky and solid; culm or straw, when it is hollow; stalk, when it supports a flower: it is round, square, triangular, smooth, viscid, canulated, straight, inclined, bent, articulated, pithy, &c. it is divided into branches, and these into boughs. The trunk of a tree is distinguished into wood and bark; the wood into ligneous substance and alburnum or sap; the bark into Epidermis and cortical layers. Botanists make use of the remarkable differences of this part in order to describe and characterize vegetables. According to this they distinguish trees, shrubs, the woody plants, the herbaceous plants, the gramineous plants, the reeds, the rushes, &c. &c. it affords many characters, species, and varieties. It is also, in this part, the
general

general support of all the rest, that we best perceive the internal structure, the real anatomical texture of vegetables, and that we observe the principal phenomena of their organization and functions, as I shall show in the following article.

5. The leaves, a kind of flat tissues, which seem to be laminated branches, composed of the same internal parts as the stalk, the ornament and verdant clothing of the vegetable, organs destined to entertain by their multiplied surface immense communications with the atmosphere, constitute the parts which differ the most from each other, and which furnish at the same time the greatest number of notions to be acquired, and the greatest part of the descriptive characters which botanists can employ in order to distinguish the several species. The leaves differ :

a. With respect to size ; some are of an enormous extent ; others are so small that they are scarcely discernible.

b. With respect to form : they are oval, round, linear, elliptic, triangular, square, tetrahedral, hexahedral, oblong, semi-lunar, pointed, truncated, lanceolated, sagittary, cuneiform, lyre-shaped, cylindrical, in the form of prisms, &c.

e. With respect to their contours or their margins, they are even, dentated, channeled, angular, undulated, truncated, lacinated, smooth, wrinkled, circled, edged with various colours, &c.

d. With respect to their appendages : they are
naked,

naked, armed, bristly, thorny, hairy, downy, aculeated, hamous, rugous, granulous, glandulous, tuberculous, &c.

e. With respect to their surfaces, or the upper and the lower side : they are smooth, polished, varnished, brilliant, dull, even, unequal, sinuous, perforated, porous, with holes, flat, convex, concave, caniculated, in the form of a cup, curved, &c.

f. With respect to colour : light-green, dark-green, red, spotted with veins, clouded, of a single colour, versicolor, painted, diversified, especially in their two surfaces, &c.

g. With respect to their simplicity or composition : they are simple or three-fold, four-fold, lobous, &c. The compound leaves have leaflets arranged opposite to each other, when they are termed opposite, or without being opposite to each other, when they are alternate ; either with or without an odd leaflet, which terminates them : they are called palmated, pinnated, bipinnated, tripinnated, according to the order of their composition.

h. With respect to the manner in which they are attached to the stalk ; they are sessile, petiolated, opposite, alternate, verticillated, amplexicaulate, perfoliated, vaginated, &c.

i. With respect to the situation which they occupy in the plant ; they are radical, caulinary, floral, axillary.

k. With respect to their consistence ; they are

soft, dry, papyraceous, silky, thick, fleshy, fat, or coriaceous.

4. With respect to their taste and smell: they are herbaceous, insipid, sweet, saccharine, austere, acid, bitter, astringent, acrid, caustic, burning, inodorous, aromatic, fragrant, ambrosiacal, fetid, virous, alliaceous, resembling some known odours, vulvury, stercoraceous, urinous, having the smell of roasted flesh, &c.

The supports which bear and attach them, or the petiolæ, which are continuous with the stalk or the branches, containing in contiguity with each other the vessels which spread themselves between their two surfaces, vary also greatly in their length, their thickness, their form, their colour, their nakedness, their defences, &c.

6. The flowers, precious organs, the masterpiece of the vegetable creation, the nuptial-bed which inclose and conceal the connubial rites of the plants, are composed of parts which defend the organs of generation, and of these organs themselves. When they contain both the external coverings and two sexes, they are termed *complete* and *hermaphrodite*; when they are deprived of some, they are said to be incomplete, male, female, with fruits, &c. The external parts, a kind of integuments, which defend or support the internal, are the calix, the receptacle, the corolla, and the nectary; the internal parts, the genital organs, are the stamens and the pistil.

A. The

A. The calix, the outermost and the thickest tegument, a continuity of the bark, the green colour and texture of which it generally possesses, is called the *Perianth* in most of the flowers, which it surrounds like a vase; *spathe*, in the liliaceous plants, in which it quits the flowers which raise themselves above it, dries, drops off, or disappears; *chaff* or *glume* in the gramineous, in which it has the form of a simple scale; *involucre* in the umbelliferous, in which it connects and incloses the parcels of flowers by its lineary and filamentous divisions; *catkin*, or a false calix; a conical or cylindrical support of a great number of monoecial or dioecial flowers; veil in the mosses; hood in the mushrooms. The calix is uniflorous or multiflorous, partial or common, hard, soft, permanent or deciduous, drying or swelling, in order to become the fruit, extremely varied in its form, its size, and all its properties; it is rounded, globular, cylindrical, dentated, divided, monophyllous, polyphyllous, simple, double, triple, smooth, canulated, spinous, hairy, glandulous, open, dilated, closed, contracted, &c. Rivinus, and several other botanists, have founded a method, or regular classification of vegetables, upon the structure of the calixes.

B. The receptacle, a sort of plate that terminates the stalk, of which it is commonly nothing else than the extremity dilated into a button, forming sometimes a distinct and enlarged fleshy mass,

mafs, fupports all the parts of the flower; the calix which forms its external circle, the border, and frequently envelope the corolla in a fecond circle, the ftamens in a third, when they are attached to the receptacle, the piftil in the centre. Sometimes the receptacle fupports the feeds uncovered after the flower; fometimes it ferves as a covering for it, and forms the fruit with the calix which remains, either entirely or in part, folidly adhering to it.

C. The corolla, a membrane of the flower, generally coloured and brilliant; that which ftrikes the eye the moft, attracts the moft notice, and really conftitutes the flower in the opinion of the majority of mankind; a femi-transparent veil, which is in the neareft contact with and fupports the male organs of generation, continuation of the liber, or the cortical layers, is one of the parts which has moft engaged the attention of botanifts. It confifts either of a fingle piece, in which cafe it is termed *monopetalous*, or of feveral pieces, when it is called *polypetalous*. Both of thefe corollas are either regular or irregular. The regular monopetalous corolla is termed campaniform when it refembles a bell; infundibuliform when it refembles a funnel. The irregular monopetalous corolla is *labiated* when it prefents the appearance of two lips at its orifice. The regular polypetalous corolla is in the form of a crofs, *cruciform*; of a rofe, *rofaceous*; of a pink, *caryophyllated*; of a lily, *liliaceous*; of a butterfly, *papil-*

papilionaceous, or *leguminous*; both of them when without any determined form are termed *anomalous*. When the monopetalous corolla is very small, and forms a long straight tube, united in the same calix with many others, and terminated by five teeth, it is termed *flosculus*; when it is shaped into a tongue at its extremity, it is called *semi-flosculus*. The flowers that have no corolla are termed *apetalous*. In the petal, or each piece of the polypetalous flower, are distinguished the claw *unguis* or narrow base by which it is inserted, and the border or dilated part.

Linnaeus compares the corolla with the curtains of the bed that conceal the married pair. When it is blown the fecundation is generally effected. Tournefort has founded his system of botany upon the form of the corolla.

D. The nectary is an appendage or part of the corolla, which contains a saccharine and aromatic juice, called *nectar*, of which insects, especially bees, are very greedy, and which they form into honey. This organ is frequently a small cavity, a ridge, a groove, one or more glands, a small open round capsule, a fissure; sometimes it is formed of branched hairs, a kind of tufts, horns, cowls, vessels, spurs, cylinders, &c.: it exists in all corollas. The bottom or folds of those which present no very distinct and well formed nectary, supply the place of it, and are found filled with a saccharine juice which filtrates in them.

E. The

E. The stamens, the male organs of generation in plants, form one of the most essential parts of the flower. When they are alone, the flower is said to be *male* : they generally consist of the *filament* and the *anthera*. The first is a support through which the nourishment is conveyed to the anthera ; the latter is a small bag filled with fecundating powder or *pollen* ; sometimes the anthera has no filament. Modern botanists have much studied the structure and the diversities of this important part of vegetables. They have distinguished in it, especially

- a.* The number, which varies in different genera of plants, from one to several score ;
- b.* The respective heights, which is either equal or unequal ; in the latter case, when there are two large and two short, they are termed *didynamic* ; when there four large and two short, they are *tetradynamic* ;
- c.* The form of the filaments, the form and the number of the anthers ;
- d.* Their separation or their union ; this is formed by means of fibres, when the name of *adelphia* is applied to them in general ; *monadelphia* when they are united into a single mass ; *diadelphia* when they constitute two ; and *polyadelphia* when they form more than two bodies. The union is sometimes effected by the anthers, they are termed *syngenesia* ;
- e.* Their attachment, either to the receptacle, or upon the ovary, or to the calix, or to the corolla. The last mentioned insertion always takes place when the corolla is monopetalous. These positions are characterized

characterized by three modes of expression. The stamen is said to be *epigynous*, when it is attached above the germ, or to the germ itself; *hypogynous* when it is beneath, or adhering to the receptacle; *periginous* when it is round, or inserted upon the calix. When the monopetalous corolla is staminiferous, its insertion, which then determines that of the stamens, is likewise triple. Linnæus invented an ingenious system according to the number, the respective size, the situation, &c. of the stamens; and Jussieu has established a still more profound and learned one, upon the manner in which the stamina are inserted into the different parts of the flower.

F. The pistil, the female organ of generation is placed in the centre of the flower: it consists of an inferior part or *ovary*, a sort of box or capsule, which contains the seeds, or determined by the seed or the seeds, even exposed in the bottom of the flower. This first part is surmounted with a cylindrical canal, more or less long, termed the *style*; the gardeners term it the shaft in fruit trees; it has at its extremity, a kind of head, button, or horn, or a somewhat dilated aperture, known by the name of *stigma*. Sometimes the stigma, without any intermediate style, is supported immediately upon the germen or ovary; in this case, it is termed a *sessile stigma*. Since the stamens have been more studied, the same attention has been bestowed upon the style, and the multitude of differences have been found,

found, and indicated in it. The number, the form, the respective position of each part of the pistil has given rise to the adoption of a long series of distinctions: the position above or below the calix and the flower, has particularly been remarked; this is a constant and very remarkable character of vegetables. Linnæus has also taken the constant varieties of the pistils in different vegetables, for the establishment of his system, and he has made them constitute the character of most of his orders, or of the divisions of his classes.

7. The relative position of the flowers is also one of the facts which most influences the appearance and the external structure of the vegetables; they are either sessile, placed immediately upon the branches or twigs, or pedunculated, that is to say, sustained by a peduncle or support, more or less long, short, straight, crooked, rigid, pliable, inclined, moveable, agitated, strong or weak, capillary, &c. They are either solitary, or arranged two and two, three and three, four and four, axillary, terminal, caulinary, verticillated, in stages, in ears, in umbellæ, in clusters, in corymbuses, in thyrsuses, in bouquets, in fasciæ, in paniculæ, in heads, balls, pyramids.

8. The fruit, which succeeds the flower, the last term in the work of vegetation, destined to perpetuate the species by the succession of the individuals, is formed of one or more naked seeds contained at the bottom of the calyx, or
of

of seeds solidly inclosed until their maturation, in coverings, which have been distinguished according to the difference of their structure into seven species. Four of these grow dry as they arrive at maturity; they are termed *capsule*, when the seeds are contained in them without attachment; *siliqua* or pod when they are attached to two skins or valves separated by an intermediate partition; *husk* or *legume* when between two skins or valves without partition, they are inserted on a single side; *cone* when they are placed upon a conical axis, and covered with ligneous shells which defend them. Three other species of fruits remain succulent; namely, the *nuts* or the kernel fruits, covered with pulp; the *apples*, or fruits with pepins, provided with a thick and tender parenchyma; the *berries*, with a soft and semi-liquid pulp, in which the seeds are inserted without apparent order or attachment, *semina nidulantia*. All fruits open at a certain period, either by the drying of their skins, and their elastic separation, which throws out and sows the grains, or by the decomposition of the pulp which constitutes them, or by the swelling and laceration of the woody shells or horny capsules which inclose the seeds. Methods or systems of botany have also been founded upon the structure and the difference of the fruits.

9. The seeds, the most admirable and most incomprehensible part of vegetables, which contain them, completely formed within a very

small volume, are in general composed of three substances : the *embryo*, the *cotyledon* or *cotyledons*, and the *perisperma*. These three interior substances are enveloped in a thin and light pellicle, which is itself covered with a solid tegument, frequently horny or cartilaginous. The latter is also almost always provided with a fat, glutinous, resinous, or mucous powder, which defends it against the action of external substances. This whole apparatus, which is also termed *grain*, varies prodigiously with respect to size and form. Some seeds are very large, whilst others elude the sight. They are spherical, rounded, compressed, ovoid, lenticular, cylindrical, reniform, subtriangular, subtetragonal, compressed, flattened, smooth, polished, varnished, rough, rugous, furrowed, canulated, striated, sculptured, naked, dentated, thorny, in the form of sails, wings, tufts, plumes, pointed, edged, &c. &c.

A. The *embryo*, which is also termed the *plantula*, or *corculum*, contains the plumula, the radicle, and a part intermediary between both ; it adheres to the cotyledon by one or two ligaments, which are compared with the umbilical cord in animals. It is a vegetable similar to that which has given birth to it, the folded and implicated parts of which are to be developed by germination.

B. The term *cotyledon* implies a white, brittle, granulated substance, of a fine texture, which is easily reduced to powder, to which the
embryo

embryo adheres. There are some plants in which it has not yet been possible to ascertain its existence, on account of the extreme smallness of their seed; these are termed *acotyledonous*. There are some in which this part consists of a single piece; these are termed *monocotyledonous*. Many contain two very distinct cotyledons, which may easily be separated from each other; these plants are distinguished by the name *dycotyledonous*.

C. The *perisperma* is a third substance comprehended in the internal texture of seeds, almost always smaller than the cotyledons, more contiguous to the plantula, frequently furrounding it entirely, lodged together with it in the cotyledons, from which it is distinguished by its colour, its texture, its taste, which is almost always acrid, whilst that of the cotyledons is generally insipid or mild. This substance is oleaginous, or carneous, or farinaceous, &c. It has not been well distinguished and described, except by the most modern botanists.

10. It is evident from this rapid sketch, which, however, is perfectly sufficient for the comprehension of all that relates to the chemical analysis of vegetables, that this apparent and external structure already establishes a very remarkable distinction between these bodies, and those of which we have hitherto treated. It is not only by the great dissimilarity of the parts of which plants are composed, whilst all the points of the same fossil are exactly similar to

each other; but still more especially by the intimate contexture, or the peculiar organization of these parts; that these beautiful productions of nature are still much farther removed from the mineral substances. It has formerly, but in vain, been attempted to establish pretended analogies of structure between the most regular fossils and the most simple of the plants; in vain has it been endeavoured to support these analogies by the figured stones, the stony dendrites, the herborizations, the fibrous stones termed fossil linen, the configurations of stones and metals in fern-leaves, &c. Crystallization itself, a sort of regular and constant geometrical arrangement of the molecules of minerals with respect to each other, in which some moderns have imagined they perceived a kind of almost organized structure, is very far from being able to be confounded with the most simple of the vegetable organizations. This truth will be placed in the clearest light by the exposition of the most simple notions, concerning the internal structure, or the anatomy of plants.

ARTICLE II.

Of the internal Structure or Anatomy of Vegetables.

1. ALL the parts of vegetables described in the preceding article, which present themselves at the mere view of these organized beings, which

which require no preparation or destruction in order to be observed or known, present in their internal parts, when dissected, a structure, a tissue, in a word, an organization widely different from the simple laminæ, or the crystalline and homogeneous molecules which constitute the fossils. No one can fail of acquiring an idea of this difference, even in the exercise of the most simple arts, and in the most ordinary operations of life. In fact, when we wish to destroy the texture of any vegetable substance, we are obliged to go to work in a very different manner than when we break or pound a fossil: the latter requires only a stroke or pressure, and divides or elongates itself into molecules or surfaces that are similar or perfectly identical. The vegetable, much less dense in its texture, may easily be bent, momentarily compressed, or even fractured by the efforts of the hands, by stroke, or by pressure; but the necessity of cutting it, reducing it into fragments dividing it into pieces, extracting from it the liquids, which also are not found in the fossils, has given rise to the invention of wedges, axes, bills, knives, scythes, sickles, saws, planes, chisels, presses, and a number of other instruments, of which the mere use shows to the most unfructed workman, that the organized structure of plants is extremely different from that of the stones, salts, or metals.

2. When the philosopher was desirous of making himself acquainted with the vegetable organization,

ation when he investigated the texture of these bodies, with the aid of delicate instruments, by sections made in different directions, the regular separation of their fibres and layers, by means of maceration in water, of the moderate action of fire, and of the observation even of the phenomena and accidents which vegetables present during their life ; when, I say, he investigated the mode of this organization, he soon discovered that their different parts were a regular or co-ordinate assemblage of solid fibres, of channels or hollow vessels, of liquids which circulate through them, of vessels which receive them, of orifices which filtrate them either outwards or into cavities of internal reservoirs, and that all these vessels, intertwined with each other, and communicating amongst themselves, were the product of an infinite development, of a growth by intussusception, entirely different from the simple juxtaposition which obtains in the minerals.

3. The labours and dissections of Malpighi, Grew, and Duhamel, relative to vegetable anatomy, have shown that plants are formed of five orders of vessels different in their organization, contained besides in larger or smaller quantity, and disposed amongst themselves in a particular manner, whether with respect to their respective arrangement, or to their number, in the different parts that have been described in the preceding article. The five orders of vessels are,
1. The common vessels ; 2. the proper vessels ;
3. The

3. the tracheæ; 4. the utricles; 5. the vesicular tissue. It is essentially necessary, in order to acquire an exact and general notion of the internal or anatomical structure of vegetables, to make one's self well acquainted with the organization of these systems of vessels, the assemblage of which forms their texture.

4. Common or sap-vessels are those which are constantly found in all vegetables, in all their parts, and which are destined to convey the sap. In general, a large part of them are collected in the stalk of plants, or the trunk of trees; they elevate themselves perpendicularly from the root to the summit of the vegetable; they turn themselves laterally in all directions, leaving between them meshes, or net-work, more or less contracted or dilated. It is not yet known whether these are real hollow channels, continued in their whole length, interrupted by kinds of hairs or valvules, as some phylologists have supposed; whether the sap is contained in their interior part, or whether it does not rather run upon the grooves or the external cavities with which they seem to be furrowed. It is generally believed that they pour this liquid into the utricles and the proper vessels: besides the sap, they also in some cases convey elastic fluids. It is the layers and parcels of these vessels which constitute the wood properly so called, or at least which every where accompany it.

5. The proper vessels are so named because they are filled with juices peculiar to each vegetable,

getable, or to each part of the same vegetable. These are real secreting organs, which separate and retain, like real insulated reservoirs, the different humours of a particular nature, which ought not to be mixed with the common juice. They are almost always situated under the bark; round and below the first cortical layers; they are distinguished, when a stalk is cut in a direction perpendicular with its axis, by the drops of different coloured liquids, very distinct from the sap, which exude from their open extremities. Sometimes they are dilated into vesicles or a kind of cells. They are connected with the common vessels.

6. The tracheæ, or air-vessels, are so termed on account of their resemblance with the organs which in insects are destined to transmit the air into every part of their bodies. These are very small filaments, more than capillary or setaceous, brilliant and silky at their surface, twisted into narrow spiral forms or worms, placed especially between the common vessels, and frequently running through and often filling up their intervals. They are distinguished in a piece of wood sawed or cleft longitudinally, by the small luminous lamellæ or spots, of a micaceous and argentine colour, which shine from all parts upon the surface of the wood, especially when it is exposed to the sun. They are obtained, insulated, and we observe them with their spiral structure very distinctly in the young twigs of the rose-shrub, when torn
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afunder, and not entirely filled. Though they seem to be destined to convey the elastic fluids, the tracheæ are frequently found full of sappy juice.

7. The utricular texture, composed of small irregular sacs, soft and compressible, full of thick juice, are found collected in the pith of the stalks; they appear to receive from sap-vessels, and to transport from thence into the proper vessels, the humours which they elaborate in their cavities, and to be especially destined for the purposes of nutrition. These are the great terminations, or the centres of the absorbent vessels, like the thoracic duct or ducts in animals. Frequently they are filled with coloured juices. There are many vegetables in which this part becomes obliterated, and is afterwards supplied only by the vesicular texture. Most of the plants, with a hollow or porous stalk, present an admirable structure in the fasciæ of utricles, which occupy their centre. The nutritive matter is particularly contained in this texture, as in a reservoir.

8. The vesicular or cellular texture is merely an expansion, or a prolongation of the preceding texture. From the circumference of the utrigo-medullary fascies proceed continued utricles, which passing horizontally through the meshes or areolæ left by the crossings and lateral divarications of the common vessels, proceed, diverging or elongating themselves, to spring forth above and on the outside of the
cortical

cortical layers under the epidermis, where they pour out the reparatory juice which forms these layers. This structure is very marked, and very easy to be discerned in all the herbaceous plants, and in young woody plants. Very sensible traces of it can be seen in the hardest and oldest wood: such are those stellated rays, which in the trunk of a tree sawed through perpendicularly with its axis, proceed from the centre, and lose themselves under the bark. Between each layer of common vessels, this cellular texture, which is so analogous to the cellular texture of the bodies of animals, forms an expansion of a more rare or less dense structure than these vascular layers, which is preserved flexible and elastic by the nutritive juice, which is there poured out.

9. From the aggregation and arrangement of these five orders of vessels results the organization of the different parts which compose the bodies of vegetables; and nothing is more proper than this consideration, to prove that this structure is extremely remote from the simple juxtaposition of the laminæ or the solids which constitute the fossils. In these the disposition of their molecules, even when regular and geometrical, depends only upon their primitive form, and their mutual attraction, modified by all the external circumstances which favour or diminish their equilibration, their approximation, their cohesion. At whatever point of their continuity we examine the contexture of
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the parts of a fossil, whatever it may be, we always find only similar molecules or particles; in plants on the contrary, we perceive, at different points of their texture, dissimilar vessels, different organs, particular and different dispositions of these vessels, communications, continued orifices of tubes or vessels, which present themselves to the observer.

10. It will not, however, be sufficient to confine ourselves to this general consideration of the intimate structure of vegetables, in order to acquire an accurate idea of the differences which distinguish them from the minerals. We must also inquire what differences this internal organization presents in each of the six different articles, of which it has been said in the preceding article, that a perfect vegetable, or one complete in its organization, is composed.

A. The fibrous root has the same texture, the same organization as the ligneous trunk or the wood: only its bark is never dry and hard, nor covered with a solid dry epidermis like that of the trunk. Moreover we find in it numerous filaments or fibres, filled with a multitude of absorbent vessels, destined to suck in the water and what it takes up from the earth, like so many syphons. In the carneous or tuberous root we see no ligneous layers, but a species of parenchyma lodged in a considerable mass of utricles or cellular texture.

B. The stalk, or the trunk, is the part of vegetables in which we are best able to discern
their

their texture and organization, especially in that which is solid and ligneous, and which belongs to the trees. In this stalk we distinguish the bark and the wood. The bark, or the external tegument of the wood, and of all the parts of vegetables, is formed, especially in trees, where we can see and detach it distinctly, of two very distinct parts, namely, the dry membranous epidermis, of a dark-grey, whitish or yellowish colour, composed of small, brittle, semi-transparent plates; and the cortical layers, applied in loose contexture the one above the other, easily to be separated into leaves, which are termed *liber*, and frequently filled with liquid conveyed to them by the extremities of the medullary prolongations, which spread themselves out upon them. The interior layers of the *liber* become, every year, an external layer of wood: this, the wood, a contexture of common vessels, proper vessels, tracheæ, utricular tissue, presents a medullary centre, prolongations proceeding from thence, and spreading out under the epidermis, annual layers of ligneous texture, which indicate the years of its growth; the interior of which, being the hardest, form the heart, and the exterior the softest, called the sap.

C. The leaves covered with the epidermis, which is common to all parts of the vegetable, consist of a great quantity of common vessels, the divisions of which form a very numerous areolæ, filled up with flat webs of utricular texture, into which a thick juice, frequently vis-

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cous and gluey, is poured out. The vessels which are transmitted into it by the petiole, in which they are squeezed together, diverge and separate into divisions perceptible to the eye in fibrous lines, and spread out in the plane surface of this part. The leaves may be very well dissected by maceration in water; they are also dissected by the insects, which eat the bark and parenchyma, so as to leave only the vascular texture insulated. They are perforated at their upper and under surface, with a great number of pores, which exhale or inhale vapours or elastic fluids.

D. In the flowers, the calixes are absolutely of the same texture as the external parts of the bark, or as the epidermis; they are in fact formed of the epidermis spread out, and sometimes swelled. The corollæ are a continuation of the liber, and contain also an immense quantity of tracheæ, so that they may be considered as a kind of pulmonary organ in vegetables. The stamens are continuous with the interior woody texture, and the proper vessels; the antheræ are small membranous purses, folded double, entirely perforated with pores through which a matter exudes in small drops, which afterwards dries and becomes the pollen, the fecundating powder. The pistil, a continuation of the utricular or medullary texture, has been compared with the female organs of generation in animals; the stigma holding the place of the vulva, the style of the vagina, and the ovary
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of the uterus. The vegetable eggs, or the seeds, are intirely formed in these organs, in which they exist previous to fecundation. From this structure of the flower it results that it may be considered as the ultimate production of the different orders of internal vessels, as their last shoot, as a species of dilatation or separation of the different internal organs; they are the admirable product of the excess of nourishment and motion in the different orders of vessels which constitute the internal texture of the plant.

E. The fruits are almost always formed in their interior part of a pulpy, fleshy, gelatinous, flabby parenchyma, which consists almost entirely of utricular texture, and through which only some common vessels transmitted by the peduncule pass: these vessels, which generally pass into the centre of the fruits, carry nourishment to the seeds, and produce, by the effusion of the ligneous juice, the shell which frequently surrounds the kernels. Sometimes this superabundant ligneous juice deposits itself in the parenchyma, forming concretions which are often improperly termed stones.

F. The seeds also are formed by the utricular texture, in the vesicles of which a pulverulent, or mucous, or dry and feculent matter is deposited, which communicates immediately by a kind of umbilical cord with the plantula, which it furnishes with the first nourishment,

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in order to effect the development which takes place in germination. It cannot be doubted that the juice deposited in this organ is the most elaborated, the most perfect, and the most precious product of the nutrition of the vegetables, as it gives birth to the most useful part, destined to maintain and multiply the species in similar individuals, which succeed each other without interruption.

ARTICLE III.

Of the Phenomena of Vegetable Life.

1. As vegetables differ singularly from the minerals or fossils in their aspect, their appearance, their external and internal structure, this difference is found still more prominent and decided, when we consider the play of the organs of which they are constituted. Vegetables have already been said to differ from minerals, in their being nourished or increased by intussusception, whilst fossils increase merely by the approximation and external addition of similar molecules. However, this general enunciation is not sufficient accurately to establish the differences which exist between these two classes of bodies.

2. It is from the same action of the parts, from the functions that are exercised by the different vessels of vegetables, that we are to derive a more precise

32 PHENOMENA OF VEGETABLE LIFE.

precise notion of their differences from the inorganic laminæ of minerals. The aggregate of the phenomena which take place in the organism of vegetables constitutes a particular life. Vegetables are justly said to live; for we see their birth, development, and growth; their existence, and the phases of this vegetable life divided into several stages, which succeed each other, and each of which present different scenes dependent the one upon the other; we see them cease to grow at a certain period, become fit for generation when they have acquired their full growth, remain for a longer or shorter time more or less healthy, and vigorous in their adult date; give birth to a numerous progeny, afterwards droop, become enfeebled, deteriorated, even fall sick, subjected to the inevitable lot of whatever possesses life, and at length arrive at the final termination of their existence, or death.

3. All these transitions, all these periods of vegetable life, which remove them far from the fossil compounds and approach them to the animals, are effected by an internal process, by successive changes which take place in the cavities of the different orders of the vessels which constitute their texture; and these changes are executed by means of regular and constant motions, which are called vegetable functions. It is not our present object to determine either the causes or the particular results of these functions. Our present object is merely to ascertain their existence,

ence, to announce its signs or phenomena, in order that we may be enabled to establish, in a certain manner, the difference between vegetables and animals.

4. Observation alone is sufficient to show that there takes place in vegetables,

a. An absorption of the liquids and fluids placed around them.

b. A motion of fluids from one part to another.

c. A modification of these absorbed liquids and fluids.

d. A separation of these liquids into different cavities, and into different natures.

e. A development of the organs or progressive growth.

f. An ejection of a portion of these bodies superfluous for nutrition.

g. A motion in some of their solids.

h. A solidification, or a formation of solid, which becomes ligneous substance.

i. A re-production of the individual.

We must cast a glance upon each of these phenomena.

5. The absorption of liquids and fluids by the pores of vegetables is a phenomenon equally certain and easy to be appreciated. The tubes of the roots, and the pores of the leaves, are the principal organs of this absorption: this is proved by the immersion of those parts into coloured liquids, and the passage of these liquids into the vessels of the plant. In this consists

what is termed intus-fusception. It is by this means that vegetables imbibe their nourishment, that the manures increase their growth or change their quality, and that soils influence all their properties.

6. These absorbed liquids form the sap, which in the spring distends the common vessels; and even, when it is very abundant, the tracheæ, the proper vessels and the utricles; it appears to move from the root or the bottom of the plant upwards into the stalks and branches; some authors believe that it descends again under the bark, and that thus a real circulation takes place. It is proved by means of ligatures, by the swellings which they occasion, by the exudations and lachrymations which it produces, the inflation of the bark. All the other proper liquids are diffused by degrees into their particular vessels, effused into cavities or reservoirs, and thus transported from one place to another.

7. In proportion as the liquids absorbed are moved in the canals of plants, and circulate in them, they become modified, their nature is changed, they become the different peculiar juices, and acquire properties which render them capable of fulfilling the different uses for which they are destined. In this manner are formed all the different materials of vessels which we shall soon examine. These modifications are so many chemical products or effects, which can be appreciated when the nature of these materials shall

have been explained, and compared with that of the nutritive substances which they absorb, and which pass into their tubes. This second series of phenomena answers to digestion.

8. In proportion as these modifications take place, and as the homogeneous liquid, known by the name of sap, is converted into different proper juices which are to become the several materials of the vegetables, these juices are rejected or separated from the general mass of sap, carried by particular channels into various reservoirs; and this phenomenon has the greatest analogy with what is called secretion in animals.

9. From these first effects, the absorption, the motion, the successive change, and the regular secretion of the vegetable liquids, follows the development, the evolution of the organs which contain them, and thence the growth, the elongation, and the augmentation of volume which they experience. This is a nutrition exactly similar to that of animals. In it we see the liquids become thickened, assume a considerable consistence, become coagulated, changed actually into solids, and thus add, as far as a certain term, that of the expansion which the fibres are capable of assuming, to the layers of the trees. It is by this effect that the distended bark cracks, is separated, and becomes unequal, rugged, furrowed, &c.

10. This development, this growth of the fibres and the layers which employs the thick-

ened liquids, does not absorb them intirely. All the matter taken as nourishment by the vegetables, and derived from the soil, the air, the manures, the water, does not remain intirely in their body. The uselefs or superfluous part is evacuated either in the form of liquids which run out by external orifices, or of elastic fluids which escape by transpiration. We shall see the nature of both hereafter. These excretions, which are sufficiently proved by a multitude of facts are also perfectly analogous with what takes place in animals.

Simple observation proves also, that at different periods of the vegetable life, and even for the exercise of the functions which they perform, several of their parts execute motions which have some relation with those which we observe in animals. Thus the petioles of the leaves bend, fold themselves, approach nearer to or remove to a greater distance from the stalks and the branches; thus the motion of contortion or flexure is almost general in the leaves which follow the course of the sun, and of which the inferior side is always turned towards the ground, whilst the superior is always directed towards the sky and the light; thus the herbaceous stalks incline themselves imperceptibly towards illuminated places. This phenomenon, which approaches to the nature of animal irritability and galvanism, is so sensible and so decided in some plants, that they fold themselves at the approach of all irritating substances,

stances, and almost at every kind of contact, as we see in the Sensitive Plant: other parts, and especially the filaments of the stamina, present it in a still more distinctly marked manner, and incline themselves almost suddenly towards the pistil when we irritate them with pointed substances, as we observe in the helianthus rue, the barberry bush, &c. Modern botanists have paid much attention to this motion of vegetable irritability; and the more the facts relative to this point in Natural Philosophy shall be multiplied, the more this phenomenon will be generalized.

12. The constant term of nutrition and growth in vegetables is the solidity which these beings acquire in the ligneous state at which they arrive: thus the production of the wood, and the conversion of all their parts into ligneous substance, resemble here that ossification which in the same manner terminates the life of animals. Every thing proves that the substances by which plants are nourished are carried in the state of liquids into their strainers, and that they at last become solid, lose their solvent, and assume the concrete form. Our present object is only to establish the existence and the generality of the phenomena, not to explain them. Accordingly, I must confine myself to the enunciation of what happens, without endeavouring to ascertain the causes which shall be explained after having studied the nature and the composition of the vegetable substances,

13. One of the most incomprehensible and most beautiful phenomena in vegetable life is their re-production. The dust of the stamens, received upon the stigma, fecundates the seeds contained in the ovary. This is proved by taking away the stamens or the anthers, which leaves the plant barren: it is proved also by the history of the female flowers of the monoecial plants, which do not bear any fruit, unless there are some male individuals in their reach, by the manner even in which they are fecundated by shaking the powder of the stamens upon their pistils; finally, it is proved by the varieties which the seeds of trees yield, when fecundated by the stamens of other vegetables. The seeds pre-exist in the ovaries, and the pollen only produces in them the vital motion, or the disposition to contract it. Without this fecundating powder, the seeds wither and dry away within their coverings. Scarcely has it touched them, or penetrated them with the vapour which exhales from it (for we do not see the whole pollen pass into the ovary), when this distends, grows, becomes the fruit, and the seed which it contains has become fruitful. After this, when buried in the earth, or penetrated with moisture, it swells, the radicle becomes elongated, and descends into the ground; the plumula, equally elongated, elevates itself into the air, carrying with it the cotyledons which present the two first leaves, or the first leaf, which on that account are termed

seminal

seminal leaves. When once it has sprung forth into the air and taken root in the ground, the young plant lives by its own strength; nourished at first by its own substance of perisperma, which forms a kind of milk, the embryo is developed, unfolded, quits this nutrient integument, and draws in its nourishment by its own absorbent pores.

14. To this series of phenomena, easy to be distinguished, and which constitute the vital functions of vegetables, we must add the property which plants possess, of being re-produced or propagated by slips, of uniting by their divided barks, of entering the one into the other, of being multiplied by suckers, of being varied and married one with another by grafting: we must also add that germination, foliation, floration, and fructification, divide their life into distinct periods; that every year the most of them repose during the winter, sleep during the cold, and begin again to live in the warm season; and we shall have in this delineation, however feebly it may be sketched, a collection of facts which will leave no doubt with respect to the extreme difference which exists between these beings really organized, and the brute and inorganic matters that have been treated of in all the preceding sections. It will easily be conceived that the chemical properties of these bodies must be very different from those of the fossils, and that the manner of appreciating them
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must be no less different from that which has been applied to those. This is the only truth which I have hitherto endeavoured to prove; and I shall finally confirm it by considering, in a last article of this first order, the general uses which vegetables fulfil in the economy of nature, and by comparing them with those to which minerals are destined.

ARTICLE IV.

Of the Uses or Functions of Vegetables in the Economy of Nature.

1. WHEN we employ ourselves with investigating the rank which vegetables hold amongst the productions of nature, and the uses for which they are destined, we discover, especially in this investigation, the most prominent difference between the minerals and these organized beings. Elevated above the surface of the globe, covering its nakedness, enriching its dryness, and substituting, instead of its aridity, the image of freshness and abundance, the vegetables seem to conceal from the eyes of man the fossils which the earth contains in its bosom, and to invite them to enjoyments which the minerals cannot procure him. Their masses shooting up into the air in the form of trees, or pressing upon the ground which they adorn with a brilliant clothing of verdure, present
equally

equally, in all points of the globe, the most beautiful, the most gay, the most delightful of spectacles, and no animated being is insensible to this rich vesture of the earth.

2. The force with which it vegetates, grows, and augments in all dimensions, when it meets with no obstacle, when the hand of man does not destroy or stop it in its course, tends to overcharge the surface of the earth with ligneous substance; and if we except the height of mountains above 3000 metres in the atmosphere, which shows the stony skeleton of the globe, always bare and always naked, the whole crust of our planet would be intirely covered with trees and wood. We see this in the places where men have not yet fixed their abode; impenetrable forests, masses of wood in close proximity with each other, occupy the whole space, and reign unmolested in it.

3. Those among these organic beings which, by the laws which every thing obeys, and after having fulfilled the limits of duration which nature accords to their existence, have perished, fall upon the ground, are slowly decomposed, and converted into a nutritious *detritus*, into an earth or soil of new formation, which forming layers successively applied over the primitive beds of fossils, gradually raise this soil, change the proportions of its principles, and constitute a mass of natural manure in which the seeds vegetate with rapidity. Thus even, from the successive death and decomposition of the one,
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the others derive the source of their life and their strength, in order in their turn to furnish an aliment to the vegetable generation which is to succeed them: an admirable uninterrupted circle of the regenerating power which watches over the preservation of all the productions of nature.

4. These immense masses of vegetables which surmount the fossils, and reign over them, detain at the same time, at the surface, the water, that first source of vegetable fertility, prevent or diminish its evaporation, absorb it from all parts, appropriate it to themselves, drink it by all their pores, produce the same effect upon the clouds or water in the state of vapour, attract them, condense them, open myriads of greedy mouths to imbibe them, and frequently retard or annihilate the dangers of heavy rains or storms for the towns which these clouds threaten to destroy. Thus it has been observed, that forests inconsiderately hewn down in the vicinity of some towns have rendered them infinitely more subject to atmospheric torrents or abundant rains.

5. The vegetables, by the intermixture of their roots, and the adhesion which they contract with the earth which surrounds them, sustain the most moveable and least tenacious parts of the soil, the shrinking of which they retard or intirely prevent; they even defend the soil from the undermining action of the water. Human industry has availed itself of this property,

perty, in order to give solidity to places most liable to be undermined or to sink, whether in consequence of the want of cohesion in the earth that covers them, or on account of the declivity of the layers upon which this earth rests, especially when they are attacked by the motion of the water.

6. Whilst they present to man the most magnificent spectacles, vegetables are destined by nature to renovate, by the aid even of their vital motions, the purity and primitive composition of the air necessary for the support of the life of animals. When acted upon by the rays of the sun, they pour into the atmosphere a vivifying stream of oxygen gas, in proportion as they vegetate.

7. The vegetables afford at the same time a defence against the heat of the sun, a salutary and refreshing shade to animals. Under their leafy vault animated beings find repose, coolness, and shelter against the winds, rains, and storms; from them they at the same time derive their nourishment: this is the most important purpose which plants are destined to fulfil in nature. Accordingly, under the dense shades of vegetables, accumulated together upon inhabited regions, and even in the very bosom of the humid slime, or the stagnating waters which their masses support, dwell immense nations of reptiles, serpents, aquatic birds, insects, and worms.

8. All

8: All the facts that have been collected relative to the economy of nature prove, that no animal can support its existence upon the fossile substances, and that without vegetables there would be no animals. It is in these organized bodies that all the classes of animals find their primitive nourishment: for those that live upon other animals devour such as nourish themselves with vegetables. Thus every living body comprehended in the numerous class of animal beings derives its first existence from the plants; thus the vegetables are destined by nature to prepare the primitive aliment of animals, and no substance can be digested by these, unless it has been previously prepared by the interior organs of plants. Considered in this extensive point of view the vegetables are a kind of beings necessarily intermediate between the fossils and the animals; they receive primitively from the first the elements of brute and inorganic matter, which they combine in a complex manner, in order to furnish it to the second, in which it is then susceptible of being converted into their own substance. They are destined to prepare the aliment of animals: accordingly, the number and the weight of these correspond very exactly with the number and weight of the former. Were there only this difference between the fossils and the vegetables, it would be sufficient to distinguish them in such a manner that they could never be confounded.

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9. To these great uses in the economy of nature, human industry, and the perfectibility of which man is susceptible, have joined an immense number for his necessities and pleasures. Without attempting the slightest sketch in this place of the arts which are exercised upon vegetables or vegetable matter, a subject which will be treated in most of the articles of this section, it will be sufficient to observe that men find in these beings, a great variety of foods together with the most commodious matter for building their habitations, that of their clothing, the remedies for the diseases to which they are subject, even the means of transporting themselves over the waves, the materials of almost all the machines which they construct and employ, especially for moving, raising, and drawing heavy burthens. They have been able to collect about them useful plants of all kinds, to multiply them, to increase their production by culture, to perfect and modify their properties in a thousand ways, to give them dimensions, odours, tastes, colours which not originally belonged to them, and to appropriate them in general to their wants and even their caprices.

Second Order of Facts relative to the Vegetable Compounds.

Of the Nature or Chemical Composition of those Beings in general.

ARTICLE I.

Concerning the Succession of Labours and Discoveries relative to this Composition.

1. IT is impossible to avoid concluding, from the facts which have been collected in the preceding order, that the vegetable organization must form compounds extremely different from those which constitute the fossils, and that the chemical phenomena which these compounds present must also be entirely different from the results which we obtain in treating mineral substances. Hence in the first labours which chemists have bestowed upon the vegetable substances, they obtained facts opposite in some measure to those which they had occasion to observe in the fossils. All the phenomena of the analyses were then so much confounded and mingled with each other in their experiments upon these organized bodies, that it required much time and great progression, in the general theory of the science, before they were able to conceive the general cause of this difference, in the complication even of the effects, combined by the analytic action to which they subjected them.

2. One

2. One of the first and most astonishing data which they collected in their rude assays upon the vegetable substances, was the impossibility which they found of restoring to these substances, when once altered by chemical operations, the original composition and nature which they had before. Whilst the mineral compounds, when analyzed with care, afforded them principles which, when re-united or combined in the proportions indicated by this analysis, formed again the compounds with all their properties, they were unable to obtain any thing similar by their experiments upon the vegetable compounds; and they remained a long time ignorant what was the reason of this phenomenon; so that they must have despaired of ever arriving at an exact notion of the composition of those beings which thus presented them, prior to the pneumatic doctrine, only an insoluble problem, an inexplicable enigma.

3. Accordingly, the whole of vegetable chemistry was still confined in 1784, to the extraction and purification of the different immediate products of plants, to the determining their relative solvents, to the search for the means of separating them exactly, the seizing the principal characters which distinguished each of these products, in order rather to make them subservient to our wants, than exactly to appreciate their nature. Confined during more than an age to the laboratories of pharmacy, or the workshops of the arts, this part of chemistry was occupied

cupied only with the preparation of medicines, and the production of the different substances useful to men for their numerous wants. If at this period we had sought philosophical ideas concerning the nature of vegetables in the analysis which the chemists made of them, we should have found nothing but errors or hypotheses: and if we had expunged from the treatises of chemistry what related to pharmacology or the manufactures, nothing would have been left for chemical philosophy.

4. After the simple and often mechanical means of extraction of the principal materials of vegetables, given by the first chemists, with the special intention of forming useful medicines from them, there was first adopted, in order to investigate the nature of these materials, and also that of the entire vegetables, the violent action of fire, by distillation in the retort; and it was so firmly believed, that the principles so obtained, had existed ready formed in them, and were only separated by the heat, that no other method of explaining their virtues was used, than that of attributing them to these principles. This we particularly remark in the works of Lemery, Geoffroy, and all the authors of the *materia medica*, from the end of the seventeenth till nearly the middle of the eighteenth century. The Academy of Sciences at Paris, even believed that one of the most important and most necessary labours to which they ought to devote themselves, was the ana-

lysis of plants by fire; and nearly thirty successive years were employed in the execution of this enterprize, recorded and described with great care in three large folio MS. volumes, preserved in the library of the Institutes, the fruit of the labours of a Boulduc, a Dodart, a Geoffroy, a Bourdelin, &c.

5. At last this method of analysis was perceived to be fallacious, and that by following this route one was led aside from the path of truth, for corn and hemlock afforded products almost similar to each other. The chemists were then for some time totally discouraged, until, always tormented by the almost exclusive wish to extract valuable medicines from vegetables, they adopted a new course, that of re-agents. They began to treat vegetables and their materials with cold and hot water, and with alcohol, to compare the different effects of these two liquors. Boulduc, Hermann, and Cartheuser, drew some useful results from this method. They calculated the different proportions of the aqueous and resinous extracts separated by this means. La Garaie taught the art of extracting the soluble materials by means of cold water applied to the vegetables in a state of minute division, with the aid of motion communicated by agitators, and of obtaining from them unaltered principles. The books of pharmacology, and of the materia medica, treated then of the virtues of plants, according to this new mode of analysis;

and the first error, proceeding from the altering action of the fire, being successively corrected by less erroneous results, gradually disappeared.

6. A little after the middle of the eighteenth century, Baccari, in Italy, and Kessel-Meyer, in Germany, found in the application of cold water, a new mode of analyzing the farina of corn, and discovered the glutinous matter, the new vegeto-animal principle, a discovery which animated the chemists with new courage. Rouelle who, in his course, had already added much to Boerhaave's beautiful scheme of the vegetable analysis, was the first who distinguished with more care the immediate materials of vegetables, divided and characterized the different kinds of extracts by better known properties; discovered the glutinous matter in the green leaves, compared the gums and the sugar with the starch; published in his processes a more complete and especially a more methodical sketch of vegetable analysis than had till then been exhibited, and re-animated the hopes of the labourers of chemistry. Bucquet, my first master, whose life was too short for the interests of science, published in the year 1773, under the modest title of *Introduction à l'étude des corps naturels tirés du règne végétal*, a work of the highest value for the order which reigns in it, and the description of the numerous parts relative to the chemistry of plants. At this period every thing was disposed for more important discoveries.

7. The

7. The pneumatic chemistry then began to arise, when Priestley and Chaulnes examined the acid gas, then termed *fixed air*, produced and disengaged during the vinous fermentation, and convinced themselves that it was the same as that which Black had found in chalk and the alkalis. Already in 1764, Macbride had admitted its presence in vegetables, in a manner too precipitate indeed, but ingenious, and calculated to give an useful impulse to the minds of men, and had attributed the putrid decomposition to its disengagement; accordingly to him, nothing more was required than to prevent this disengagement, or to restore this principle to vegetables, in order to prevent or correct their septic alteration. Though this first introduction of the pneumatic chemistry into the analysis of vegetables, from 1764 to 1784, gave rise only to false notions, it was, however, of service to the science by the discoveries, insulated and incoherent indeed, which it produced. The epocha of the discovery of the nature of water, followed soon by that of the nature of fixed air, which was found to be carbonic acid, was a flash of light for vegetable analysis. Lavoisier, by examining the products of the combustion of oil and of alcohol; by obtaining more water than their own weight amongst these products, as well as a remarkable quantity of carbonic acid gas; by studying with equal care the phenomena of vinous fermentation, opened a new path, and threw a great light upon the vegeta-

ble composition; explained the nature and the source of the products which till then had been extracted by means of fire, why they could not be contained in the vegetables previous to this action, how they were formed. Thus the first accurate notion of the organic compounds presented itself. Since this illustrious period the steps of the chemists, which halted before, have become steady; the science has proceeded from discovery to discovery. There has particularly resulted from it an ingenious and useful comparison between the different means of analysis till then employed, that by fire, by combustion, by distillation, by fermentation. Hence also arose the simple idea of vegetable composition, which will be traced in one of the subsequent articles. My design here is merely to present in a single point of view, and under a single feature, the result of Lavoisier's labours upon vegetables.

8. All the discoveries relative to vegetable analysis, which have been made either some years before 1784, or since, may be referred to the new ideas diffused by Lavoisier, of which they are only approximations and necessary consequences. It is in this order that we ought to place those of Bergman and of Scheele, especially of the latter, who has done more towards the improvement of this analysis, than all the chemists collectively had done from the commencement of their labours. Prior to these, scarcely two or three vegetable acids different
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from each other were known. In 1776, Bergman discovered the conversion of sugar into a particular acid by means of the nitric acid, and Scheele soon found that this acid was the same as that of sorrel; and from this first source of the artificial fabrication of a vegetable acid have proceeded many other similar discoveries. The last mentioned chemist successively discovered the particular existence of the citric, the malic, the gallic, the sacchlaric acids, and gave occasion to the successive labours of Crell, Hermstaedt, Westrumb, Kosegarten, and Brugnatelli, relative to the formation, the resemblance, the difference, and the mutual conversion of the acids; discoveries which have furnished the French chemistry with the opportunity of applying its doctrine in so happy a manner, as we shall soon see, to the nature and composition of all the vegetable substances. I do not here speak of many other particular facts which we owe to the same Swedish and German chemists, and which I shall have occasion to quote elsewhere.

9. During, or shortly after, these useful discoveries of the Swedish and German chemists, Ingenhousz and Sennebier, examined the elastic fluids exhaled from plants, the action of vegetables upon different kinds of gas, their influence upon the air, and that of this fluid, of water, and of light upon the vegetables. Their labours approach in a singular manner to the first data found by Lavoisier; and though they had taken routes entirely contrary, they in
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some measure met in the career which they had run, by beginning each at opposite extremities. Hence results the most beautiful conformity that can be found in the history of the sciences; and it is from a comparison of the collective mass of their labours, that the important application has sprung which has began to be made of the truths of chemistry to the phenomena of vegetation. It is from this period that the happy revolution that has been effected in vegetable physics truly dates itself; a revolution, the actual state of which I shall delineate, after having considered all the facts which constitute the whole of the analysis of plants which at present exist.

10. Citizen Berthollet has, on his part, rendered the most important services to vegetable analysis. His labours upon the oxygenated muriatic acid led him, in examining its action upon the vegetable colouring substances, to determine its nature, and the diversities of its colours, to explain their alterations by the air, and to understand the remarkable influence of oxygen upon the oils, which it thickens, and causes to pass into the state of butter or wax. By other experiments and researches, he has discovered the slow and spontaneous decomposition of the tartarous and acetous acids, and of their salts dissolved in water, the portion of pot-ash ready formed, which the first contains, the attraction of the colouring matters for alumine, and for the oxide of tin, the decompositions of the tartrate
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of antimony, and of the super-oxygenated muriate of mercury by the decoctions of Peruvian bark. May I be allowed to rank myself amongst the list of chemists who have improved the vegetable analysis, on account of the results which I have published in various particular dissertations, relative to the different coloration of the extractive matters by different proportions of oxygen; concerning the properties of the extracts described in my analysis of the Peruvian bark; concerning the conversion of the ligneous substance into several acids by the nitric acid; concerning the separation of elastic caoutchouc from the juice of the *hevéa* exposed to the air; concerning the reciprocal action of the nitric, sulphuric, muriatic acids, and the vegetable substances. I have, moreover, undertaken an extensive course of inquiries upon vegetable analysis in general, in conjunction with Citizen Vauquelin, of which I shall exhibit some portions in this work, though these inquiries are yet far from being completed. I pass over in silence a great number of other tracts in the history of vegetable chemistry, and the discoveries which we owe to M. Proust, to Pelletier, to Citizen Chaptal, who has rendered great services to the chemical arts relative to these substances, to Citizens Deyeux and Vauquelin, and to several other chemists, as these facts will find their place in most of the subsequent articles, and as most of them do not present that generality of results which alone can make them
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be considered here as having influenced the progress of this part of the science. My intention was here only to announce or exhibit the most prominent traits of different epochs of the analysis of vegetables, those which have really changed the face of the science, and have raised it to that degree of elevation at which it has arrived.

ARTICLE II.

Of the different Methods of Vegetable Analysis, compared with each other.

1. FROM what has been explained, though very succinctly, in the preceding article, it results, that at the different periods through which the art of chemistry has in some measure passed before it arrived at that period of improvement which it now has attained, the methods of analysing vegetables must have varied, and actually have varied. However, nothing has been lost in this respect; even the faults of the antient methods have been turned to advantage; useful inductions have been drawn from them towards the establishment of new ones; they have been compared with each other, and this comparison itself has furnished new and sometimes unexpected lights. In proportion as by rectifying its errors, chemistry has created new methods, it has not entirely abandoned the ancient ones; it has resumed them under a new point

point of view, and corrected them; so that even the inaccuracies of their results have then given place to positive data. These methods have therefore mutually checked each other.

2. When we consider, under one point of view, all that has been done more than a century past relative to the analysis of vegetables, and bring together the different means successively employed for investigating the nature of plants, we may refer all the modes of treating them that have been adopted, to eight general methods; namely,

- a.* The natural mechanical analysis.
- b.* The artificial mechanical analysis.
- c.* The analysis by distillation.
- d.* The analysis by combustion.
- e.* The analysis by water.
- f.* The analysis by the acids and the alkalis.
- g.* The analysis by alcohol and the oils.
- h.* The analysis by fermentation.

By giving a concise notion of the operations and uses of each of these kinds of analysis, we do not yet attempt to determine with exactness the chemical properties of vegetable substances. This subject belongs to the third order of facts, which shall be treated of in particular after this; but we only continue to exhibit the means which chemists have taken in order to arrive at the knowledge of these properties, and acquire an accurate idea of the difference between vegetable and fossil substances; in a word, it is only a sequel, and one
of

of the necessary portions of the historical part which forms the general subject of the four articles comprehended in this second order of facts.

3. Though the separation of the different substances of which vegetables are composed, effected by mechanical means, is not really comparable with the means of chemical analysis, I rank it amongst the methods of analyzing plants, because it actually serves to insulate the materials of which they are constituted. This first means I term the *natural mechanical analysis*, because it is effected by nature. When any proper or particular humour swells the vessels or reservoirs in which it is contained, and cannot remain longer in them on account of its superabundance, it breaks the membranous walls which contain it; it runs out spontaneously, and appears on the outside of the plant in the form of an excretion. Naturalists and Chemists avail themselves of this circumstance, in order to collect and examine the products of these excretions as materials of the vegetables which afford them: frequently they even increase their abundance, by enlarging the natural orifices through which these liquids flow out, or by making artificial orifices. In this manner are obtained the sap, the gums, the saccharine juice, manna, the volatile oils, the resins, caoutchouc, &c.

4. I consider as the second method, which I term *artificial mechanical analysis*, the extrac-
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tion of the different substances which are obtained by breaking the cells or the vessels by various mechanical instruments differently disposed, according to the nature and texture of the plants, such as mortars, files, presses, mills, &c. It is in this manner that we obtain the juices of plants, the mucilages, the fixed or volatile oils. This method, by which not only the liquids are separated from the solids, but also the different juices; oily, mucous, extractive, coloured, acid, saccharine, &c. and the different parenchymas, lamellated, fibrous, the gross fecula, or the fine and amylaceous fecula, is one of the first that are employed upon vegetables in order to obtain their different constituent materials. It possesses the advantage of not changing the nature, or producing any alteration in the materials, and of affording them such as they are in the vegetables; it is much employed in the arts.

5. The analysis by distillation is, as I have already observed, the first means which chemists have employed; and for a long time it was the only one. The vegetables were first distilled with a gentle fire on the water-bath, in order to extract the water of vegetation; and treated in boiling water to obtain the volatile oil. They were put into retorts of stone-ware or iron, to which a receiver was adapted, in which were condensed the more or less saline phlegm, the oil or oils, the volatile salt, or the carbonate of ammonia, of those vegetables that afforded any.

any. Since the new discoveries, there has been added to it an apparatus for collecting the elastic fluids that are disengaged at the same time with the preceding products: there remains a coal more or less dense or rarefied, retaining or having lost the form of the first vegetable substance which has been decomposed. This is a really false or complicated analysis, which gives, as I have already announced, substances formed by the action of the fire itself, which do not exist in the vegetable, and are manifestly composed by the influence of the caloric upon the first constituent matter of the vegetables. At present it is employed only for the purpose of comparing and opposing its effects with those of the other analytic methods, and deducing from this comparison of the liquids and solids of vegetables, the differences or analogies which these may present, either in the different species of plants, or in the different substances of each plant: alone, it would merit no confidence. Combined with other analyses, this may afford great lights and very useful results, as will appear very clearly when we shall come to develop the nature of the influence which caloric exerts upon these organized beings, and upon the matters of which they are composed. The Pneumatic Chemistry has particularly served to render this mode of analysis useful.

6. When we burn plants or their products, it is sufficiently known that all these substances are more or less combustible. It is not merely with

with the intention of observing, (which however ought not to be neglected) the mode of their combustibility, the form and the nature of their flame, their smoke, or their odour,—but particularly in order to determine the quantity of coal which they are capable of yielding, the nature of the coal, dense or rare, heavy or light, porous or solid, easy or difficult to be burned, saline or not saline; to ascertain by incineration the proportion and the properties of the ashes which they yield, the quantity and the nature of the ashes which they contain, especially that of which alkali forms part, as also the metals or the metallic oxides which may be concealed in them. This *combustion* is performed either in cast-iron vessels, in which the action of the fire is moderated by smothering it, by which means we obtain coals or ashes not completely burned, and more or less oily, which were formerly termed fixed salts, prepared after the manner of Tachenius; or it is performed in the manner in which wood is burned in new furnaces, or on a clean hearth, upon a grate of earth or wrought iron. It is by this process that alkalis are obtained.

7. The *analysis by means of water*, consists in applying in general this liquid to vegetables, or to the different parts of plants, in order to separate from them whatever soluble matter they contain. Under this point of view, all the immediate materials of these beings have been divided into two classes; the one of substances
soluble

soluble in water; the other of insoluble substances: endeavours have been made to determine the relative proportion of these two kinds of substances. Water may be employed in five ways upon vegetable substances. Either they are left to soak in this liquid cold, which is termed *maceration*, or *cold infusion*. In the second, these substances are put, divided, and in the state of a more or less fine powder, into large quantities of water, in which they are agitated for a longer or shorter time by means of agitators. This was the method of La Garaie, by which he obtained beautiful extracts, which he improperly called *essential salts*. According to a third process, hot or boiling water is poured upon the vegetables or their products, and suffered to cool upon them: this is called *infusion*. A fourth consists in heating water slowly and gently upon these bodies, and constitutes digestion, which draws out more of the matter than infusion, and extracts even more than maceration, in the method of La Garaie. Lastly, the fifth method is decoction; that is to say, the operation in which water is made to boil upon the vegetable substance. This last species of action takes away much more matter from the plants than the four first; but besides that, it fuses and carries away several without dissolving them; and also tears away others from the solid texture, and holds them only for a time suspended; it changes the nature of the vegetable substances

to a certain degree, alters their composition, destroys the equilibrium of their principles, and does not afford the materials which the boiling water dissolves, without causing them to experience a very remarkable alteration.

8. The analysis of vegetables *by the acids and the alkalis* does not belong, as was formerly believed, solely to the menstrual analysis, or the action of the simple solvents. The acids and the alkalis, at least, unless very much diluted with water (for in this case they scarcely act in any other manner than as solvents), produce a very great alteration in the materials of vegetables. When they are strong and concentrated, they suddenly change the equilibrium of the composition of these materials; they change their nature; and if we should afterwards take these materials thus changed for the true principles of vegetables, we should commit the same error as was committed by the chemists, when they believed that the products of the distillation of vegetables existed ready formed in them, previous to the action of the fire. Without explaining here how these singular alterations of the vegetable substance produced by the acids and the alkalis are effected, which will be examined in detail in the order of facts that will follow the present,—it is sufficient to know that the modern chemists have found, from the data of the pneumatic doctrine, the true cause of these alterations, and that it has led them to a better knowledge of the vegetable

getable-compounds, than could have been hoped for prior to the establishment of this doctrine. Since this important discovery, the action of the acids and of the alkalis is no longer attended with obscurity, and they have even become one of the most valuable and most useful instruments of analysis that can be employed, in order to determine the vegetable composition with accuracy.

9. By applying the oils, alcohol, and ether, three substances themselves of vegetable nature, to the analysis of plants, it has been observed, almost since the commencement of the eighteenth century, that these substances have the property of dissolving some of the materials of vegetables without acting upon the greater part of the rest, and that they may thus serve to separate these materials, and to indicate their relative proportion. They are sometimes employed before the water, sometimes after the action of this liquid; and according to the products obtained by the one or by the others, the relative quantity of the different principles which constitute them is compared. It has been seen, in the preceding article, that after having renounced the false inductions which they had drawn from the action of the fire, chemists had recourse to that of water and of alcohol; they then considered only what each of these solvents took from the vegetables to be the real principles of the plants; what remained insoluble both was considered as earth, as a *caput mortuum*, and they committed

committed this second error, because they considered the vegetable analysis only with relation to the art of healing, and because they thought that this insipid residuum was no longer capable of producing any action upon the animal economy. They did not conceive that some materials of the vegetables might escape the successive action of these two solvents; and this was a second error, which insinuated itself into the results which they deduced from their first experiments; but these errors, which at present are well detected, no longer obscure the science, nor retard its progress.

The inductions which the action of these three species of chemical instruments affords, are much more exact than they formerly were, since their mode of acting has been better appreciated, as shall be shown in the following order. They are therefore justly ranked amongst the most advantageous means of analysis that can be applied to the knowledge of vegetables.

10. Finally, the eighth and last kind of analysis, which I distinguish in the chemical examination of vegetables, is the *analysis by fermentation*; that which nature employs in order gradually to decompose these organic bodies, when being deprived of life they no longer belong to the class of beings that are useful to her views, nor maintain their rank in the order of her economy. The chemists have drawn this means of analysis from the very bosom of nature, and they have nothing more to do in

order to employ it for their purposes, than to encompass as it were the vegetable substances with circumstances and conditions which give rise to fermentation. It is by the play of the multiplied attractions between the different primitive principles of plants, that the motion of fermentation is produced; the equilibrium of their composition is broken; their arrangement, their intimate disposition, change more or less rapidly, and thence arise new products, the properties of which, when examined with attention, enable chemists to conjecture what the substances were previous to their degeneration: it is, like every other chemical change, an equation of which some parts have done nothing more than change their place, and passed from one member to another, and which affords, when well understood, a more or less satisfactory solution of the problem which we wish to resolve.

ARTICLE III.

Of the general Results of the different Analyses with respect to the Vegetable Composition.

1. AMONGST the eight distinct species of analysis which I have enumerated and described in the preceding article, we must admit an essential distinction, an important division into
two

two genera ; the one in fact consists of immediate analyses, which serve to extract from vegetables the different compound substances which form their texture, without altering them or changing their nature ; they afford, as products, what have been termed immediate or proximate principles of plants, the entire materials which are found ready formed and contained in their vessels and their reservoirs, such as their juices, their saps, their mucilages, their oils, their fecula, &c. Dissection, pounding, pressure, are especially the means of this analysis. A slow fire, the application of water, of the oils, without the aid of a strong or long-continued heat, answer the same purposes ; they separate the compounded materials of the vegetables to which they are applied ; and by thus insulating these different materials, they give, as their first result, the number and the relative proportion of these first component parts, which are themselves compounded ; so that they may already serve to show the great difference which subsists between them and the fossils.

2. This however is nothing more than a first point of the vegetable analysis, and is far from being what chemists either could or ought to have contented themselves with. After having separated and obtained the immediate materials of the vegetables, they soon discovered that these materials themselves are compounds much more complicated than those which are found in minerals ; and the means which they have suc-

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cessively

cessively put in practice, in order to investigate the composition of these immediate materials, belong to the second genus of analyses, the difference of which I shall proceed to show. These analyses, no longer like the first, simple extractions, mere insulations of the materials of which vegetables are immediately formed, they attack more or less profoundly these materials themselves in their intimate composition : of this order are the more or less ardent action of fire, that of water aided by heat of combustion, of the acids, of the alkalis, and fermentation ; whence it follows, that amongst the eight species of analyses there are some which can never be any other than immediate, or not altering analyses, such as the mechanical act of expression, &c. others may either be the means of immediate extraction, when they are employed with moderation or little energy, as fire, water, the acids, &c. Lastly, several of them never act otherwise than as altering and decomposing means, such as the action of the concentrated and powerful acids, combustion, fermentation.

3. It was by observing the effects of these destructive means, of this second species of analysis, and especially the decomposing power of fire, to which, for so great a length of time, they had almost exclusively recourse, that chemists had conceived ideas, undoubtedly inaccurate and even erroneous, relative to the constituent principles of vegetables, but nevertheless such as they were then able to conceive. Their inaccurate instru-

ments,

ments, and the profound ignorance in which they still were, of the nature of the substances susceptible of assuming the gaseous form, all of which they took for air, had led them to imagine that vegetables were composed of fire, air, water, and earth, and these in fact were what they obtained, or believed they obtained, as the last result of the analysis of vegetables. The gaseous carbonic acid and hydrogen gas passed at that time for air; they neither knew how to collect them, nor how to determine their differences from the air strictly so called; they suffered them to escape through the tubes and the open extremities of the apparatuses; they were so many products which they neglected, or which they confounded with the fluid of the atmosphere, in which they suffered them to be dissipated. The liquids which they obtained, the water which formed their general base, appeared to them to be entirely contained in the vegetable matters; they were ignorant that this was a compound which might be formed in a direct way by the torture to which they subjected these substances, and that its elements, separated from their state of water, might exist merely as particular principles in the plants. The coal which they observed appeared to them to be earth, and they had no idea either of the indestructible nature of carbon, or of its properties, or of its existence as a principle in organic bodies. Long did this opinion of the primitive composition of vegetables

getables by fire, air, water, and earth, reign in the schools, and it received the happy modification at which it has since arrived, only by the series of discoveries, and of luminous ideas that have followed the establishment of the pneumatic doctrine.

4. By means of these discoveries, modern chemists have found that the last term of vegetable decomposition is almost always water and carbonic acid; that in order to obtain these last products of the analysis of plants, nothing more is necessary than to destroy the equilibrium which kept their principles united; that all the oxygenated bodies, or those capable of yielding oxygen, by adding that which was wanting, in order separately to saturate the carbon and the hydrogen, contribute especially to effect this total decomposition; and that thus hydrogen, carbon, and oxygen, were found to be the constituent principles of vegetables. The union of these three primitive bodies presents in the ternary compounds a species of mixed combustible in part saturated with oxygen: these are a kind of oxides with binary radicals, in which the three principles which reciprocally saturate each other, are united by attractive forces which balance each other in such a manner as to keep up amongst themselves the equilibrium and repose, which constitute the essence or the intimate nature of the vegetable compounds.

5. The difference of proportion between these
three

three principles causes these organic compounds to vary and differ from each other, and thence arises the diversity of what are called the immediate materials of vegetables, the mucilages, the acids, the oils, &c. but the attractions which keep these three simple bodies united with each other, are capable of experiencing great and frequent alterations, of diminishing and augmenting in such a manner, that the equilibrium which approaches them together is easily broken: accordingly, these compounds, more complicated than those which are found in general in minerals, admitting between their principles, which are more numerous, and at the same time less approaching to each other, a greater number, and consequently a greater variability of attractions, are much less permanent, and much more subject to changes, than what are found in the fossils. Fire, which separates the molecules of bodies, and diminishes their attraction; water, which penetrates and tends to separate them; fermentation, which equally tends to insulate them; all that can influence this complex composition, the equilibrium of which is so easily destroyed, quickly dissolves the link which keeps the principles in union with each other, varies their nature, modifies them incessantly, but always at last converts them into the two binary compounds, water and carbonic acid, which are constantly the last results of all the chemical operations to which we subject vegetables.

6. Thus

6. Thus we may conceive the multiplied changes which the vegetable compounds undergo between the two extreme terms of alteration which are produced in them by the different modes of analysis to which they are subjected. From the moment when any agent, applied to a vegetable substance, begins to destroy the equilibrium of the attracting forces which exist between their three general constituent principles, the hydrogen, the carbon, and the oxygen, to that period at which this agent dissolves them entirely, by uniting both the combustibles with the oxygen in particular, till it is reduced entirely into water and carbonic acid, the vegetable matter passes through a great number of intermediate degrees of composition, in which the carbon is more or less insulated or diminished; the hydrogen becomes equally either predominant or diminished; the oxygen is detached with a portion of the hydrogen, or even of the carbon, or united in a fixed state in a larger proportion than before with this substance. We also see it become coloured, softened, fused, swelled, change its taste, its solubility, become oleaginous or acid; in a word, it assumes a great number of modifications dependent upon the change of proportion and of equilibrium amongst its first principles.

7. We must therefore consider in general the vegetable substances as compounds, at least triple, of carbon, hydrogen, and oxygen; as a kind of oxides, which vary from each other as they pass out of the hand of Nature, in the
primitive

primitive proportion of their principles; very subject to alteration in this proportion itself, which, by this change of equilibrium, afford in the different states which they are capable of assuming, important inductions to the chemist relative to their composition; which frequently permit us to appreciate more especially this relative proportion between the different materials, which are compared with each other, upon which art operates, whether by diminishing or by augmenting this proportion of certain principles, so as to modify them, and cause them to pass from one state to another, and thus to seize in some measure, through these transitions, the modifications of the composition of the substances which experience it. Here I have only to announce the generality of these principles; the details and the facts in some measure specific, which are deducible from them, will be exhibited in the articles of the subsequent orders.

8. It is to the same consideration concerning the general nature of the vegetable compounds, that we have to refer the impossibility which chemists have hitherto found, of forming in a direct way a substance analogous to that which the plants afford. We have seen in some of the preceding sections, and especially in the second, that it is possible to unite sulphur, phosphorus, and carbon with hydrogen; that this latter combination exists particularly in carbonated hydrogen gas, and in the vegetable coals; but when we attempt to add to this binary combustible the
oxygen

oxygen which would be necessary, in order to make it approach to a vegetable compound, either the union is not possible, or in proportion as it is effected, the carbon and the hydrogen separate the one from the other, and combine separately with the oxygen; and if we reflect for a moment, we find that all the phenomena of vegetable analysis consist in this. The art of chemistry is permitted to insulate, and to destroy the union of the principles in a vegetable compound. As soon as it acts upon this compound, it first destroys its equilibrium; and however slight its action may be, it tends to change the nature of its composition, to convert it into another, to modify it by entirely destroying a portion of it: but it can never augment a vegetable substance, at the same time leaving it such as it is; its means, its instruments are too violent, too penetrating, too active; and to nature alone is reserved the power of creating, reproducing, in a direct way forming the first elements or primitive matters of the vegetable compounds. This last subject, which is of great importance, will be sufficiently developed in the subsequent article.

ARTICLE IV.

Of the Results of Vegetable Analysis in general, applicable to the natural Formation of the Materials of Vegetables during their Life, and to their Alteration after their Death.

1. SINCE all the most exact analyses have shown that the vegetable substances are formed, in their first principles, of carbon, hydrogen, and oxygen, to which are added, but only in some cases, and not as indispensable accessories, azote, sulphur, phosphorus, &c. it is very evident that the problem of the natural formation of these compounds consists in knowing whence the vegetables derive these primitive substances, and how they appropriate them to themselves, and thus combine them three and three. This problem in fact comprises the whole of vegetable physics; and it is not in these first considerations with which I am here occupied in the articles that form a sort of introduction, or preliminary discourse, to the analysis of plants, that I can, or even ought to discuss it in its full extent. I here intend only to point out that intimate relation which subsists between the generalities even of the knowledge we have relative to the vegetable analysis, and the facts which

which appertain to vegetation : this is the only object to which I can now attend.

2. What I have said above concerning the impracticability of composing a vegetable substance by chemical means, as yet, though we are not denied the hope of being hereafter able to do it, and though the same has perhaps already been done without our being aware of it, especially with respect to mucilage, the most simple perhaps of the materials produced by the organized bodies,—what I have said necessarily refers to the creative or plastic power which vegetables enjoy during their life. The very act of vegetation consists in forming for their own development, for the extension and the nutrition of their parts, the different immediate materials which constitute them. After having drawn in by their roots and by their pores, which are always open, caloric, air, water, carbonic acid, carbon itself in a state of division, which is furnished to them by the soil charged with natural or artificial manures ; the vascular, and especially the utricular organs, which everywhere form their texture, appropriate to themselves these nutritive principles, recompound them, and effect with them, by a succession of chemical phenomena or forces, the ternary combination, or compositions, which constitute their liquids and their solids, or their immediate materials.

3. It is sufficient in this place, if we well understand that the formation of the vegetable compounds

pounds is the product of the chemical attractions, which exert themselves in the organic instruments of the plants; and consider whatever takes place in vegetation, in the chemical vegetable constitution, as a series of operations, of natural analyses and syntheses, the determination of which, though easy to be conceived in general when the nature of these organic compounds is understood, must depend immediately upon the processes we have described in explaining the nature of these same compounds. No doubt can remain respecting the influence which the chemical analysis of vegetables must have in the appreciation of the phenomena of vegetable life; and when we shall have informed ourselves in detail with all the properties of those beings, we shall see what great services chemistry has already rendered, and especially how many are still to be expected, from the application of the modern or pneumatic chemistry to the philosophy of plants.

4. The exposition of the general nature of vegetable compounds is no less important for understanding that of the different and numerous alterations which they are capable of experiencing after their death. In general, the totality of these alterations is to be considered as the necessary consequence of their complicated composition, and of the play of the multiplied attractions which re-act between the different constituent and primitive principles which form them by their union. This equilibrium,

librium, which keeps their elements united, is so easily disturbed, and this perturbation is ordained in such a manner by nature, it enters so immediately into the plan of her economy, that it is the course which she causes the vegetable substances to take, in order to make them restore in some measure the portion of matter which she had lent for their organization, and return it to the common receptacle of its perpetual circulation and employment. This character of destructibility depending, as I have shown, upon the nature of their composition itself, is one of the greatest differences that can be established between the vegetable matters and the fossil substances. The latter always remain in the same state, at least as far as relate to themselves, and are alterable only by external causes and accidents ; whilst the former contain in themselves, and by reason of the complicated attractions of their multiplied component parts, an intimate principle of alteration, and of spontaneous destruction, dependent upon their order of composition, which prevents their remaining for a long time in the same state.

5. The same general data, relative to the composition of the primary materials, also diffuse the greatest light over the arts which are occupied with these matters. It has been seen that all the species of vegetable analysis may be considered as belonging to two genera ; the one in fact does nothing more than extract, without altering,

tering, the immediate materials of vegetables; the others modify, change, alter, and decompose them more or less powerfully, either at the very moment in which they are extracted from the plants, or a longer or shorter time after they have been extracted. The arts which are exercised upon vegetable substances, if we except those which only change their form or external dimension, have equally the double object, either of separating some particular matters from vegetables, in order to obtain them insulated and more or less pure, or to convert these matters into new products, modified and appropriated to the different uses of society. Now in both cases, they are referrible either to simple extraction, or to the more or less advanced decomposition of the immediate materials of the vegetables. This general view is sufficient for the present, to show the relation which subsists between the chemical knowledge that has been acquired respecting plants, and the arts whose object it is to employ them for the benefit and prosperity of men united in the state of society. The articles comprised in the subsequent orders will give much more perspicuity and fulness to these first notions.

Third Order of Facts relative to the Vegetable Compounds.

Of the Chemical and Characteristic Properties of Vegetable Substances in general.

ARTICLE I.

General Observations concerning these Properties.

1. THE details which I have given in the preceding order relate only to the composition of the vegetable substances in general. They show in what this composition consists; they exhibit the notions that have been adopted, and the facts that have been ascertained by the latest discoveries of science relative to the nature of the vegetable compounds. After they have been well considered and understood, they must naturally lead us to the investigation of the chemical properties which characterize these compounds, the exposition of which they render more easy, and their theory more luminous.

2. I call those the chemical properties of vegetable compounds, which, shown in the manner in which those compounds, when deprived of their life, or separated from the living vegetable are affected by the different re-agents, to the contact of which they are exposed, the changes they experience

experience, and the new results which they afford. It must undoubtedly be here expected that great differences will be found between the organic matters, and the mineral or fossil substances. In general the first, being more complicated in their composition, are infinitely more changeable by the action of these bodies, and the alterations which take place in them must be more multiplied, more difficult to be understood or well explained, than those that have been indicated in the history of all the preceding substances.

3. As this new part of the science has not yet been treated and developed in a sufficiently extensive manner in most of the works of chemistry, and as in general the vegetable analysis has not yet received, in the elementary books, that extension of which it is susceptible, and which alone is capable of affording an adequate notion of its present state, as well as of accelerating its progress, I have thought it incumbent upon me to treat of the properties of vegetable compounds in general, before speaking of their immediate materials in particular. By this means the history of the latter will become much more perspicuous, and will require no additional details, which would occasion a great number of repetitions.

4. Amongst the alterations which constitute the effects of the different agents upon the vegetable compounds, and which determine the chemical properties of the latter, though they all

tend to their decomposition, and at last even produce it completely, there are several which are only a kind of conversion of the one of these matters into the other; and this is one of the characters most intimately connected with their nature. Considering them all under this point of view, we should be led to say, that there is only one single vegetable substance in general, susceptible of a number of modifications, of successive transitions from its first state, or most simple composition, to its complete decomposition. Thus we are induced to believe that mucilage is the first vegetable compound, that which is the least remote from the fossils by its simplicity, and that the acetous acid is in this genus the last term of the composition; so that, when we shall well understand the successive alterations or modifications which the vegetable matter is capable of undergoing, we shall be able to arrange in a natural order all the immediate materials of vegetables, which are really nothing more than co-ordinate and necessary transitions of the vegetable compound from one state to another, and of which it is necessary only to determine accurately the relations and natural arrangement.

5. Under this head of remarkable permutations, it is that we ought to arrange all the changes of which the vegetable substances are susceptible, or all the chemical properties which characterize them, and are only the different effects of those changes. Hence it happens, that

that however different the agents or the instruments may be which must be employed in order to determine these properties, they all resemble each other in their ultimate or more energetic action; or at least there subsists between them, in the mode of their effects, relations, or analogies, which I shall not neglect to point out. Thus all the re-agents proper for changing the nature of vegetable substances modify them at first, cause them to assume different states, which separate them into different compounds less complicated than they were at first, and all equally conclude with reducing them, as the last result, into water and carbonic acid.

6. But though this analogy, so illustrative of the effects of the re-agents, is connected with the very essence of the vegetable compound, though I observe that I here consider the whole mass of the materials of vegetables only as a single compound, as a kind of matter produced by the work of vegetation, I am obliged, in order to enunciate all the modifications which this substance is capable of experiencing from the different agents, and which constitute its real chemical properties, to distinguish these into as many particular effects as there are agents or instruments capable of enabling us well to determine these properties. This method will have the advantage of suffering nothing of importance to escape, and of presenting the regular series of all the modifications which the vegetable matter can and actually does assume.

I distinguish all the chemical properties of the vegetable substance in general, considered here as a single genus of compounds, into seven phenomena, according to the number of agents which exert their energy upon this matter. These seven phenomena shall have the titles of actions of fire, of air, of water, of the alkalis, of the acids, of the salts, and of the oxides and metallic solutions. By considering the whole in succession, we shall not only ascertain the degree of perfection which the science has already acquired, but also the elevation to which it may still hope to arrive, and the perfection which it ought to attain.

ARTICLE II.

Of the Chemical Properties of Vegetable Substances treated by Caloric.

I. BEFORE I here determine with precision what are the chemical changes which caloric produces in the vegetable compound in general, I must distinguish those which it causes it to undergo, according to the different proportions of its accumulation, or according to the degrees of temperature. Four phenomena present themselves here, and ought to be successively examined; the one is inspissation or desiccation; the other answers to what is termed distillation on the water bath; the third is coccion

tion or baking; the fourth the total dissolution of the principles, whether in close or in open vessels. The three first are only partial decompositions simple changes, or modifications; the last is the complete decomposition.

2. No one is ignorant, that however mild the temperature may be, and however moderate or slight the quantity of heat which is accumulated in a vegetable substance, whether liquid or solid, its nature is gradually changed, indeed in a longer or shorter space of time, and in a more or less feeble degree. Thus, by the heat of a stove, the vegetable liquids are thickened, their colour grows deeper, they assume viscosity, consistence, and even a perfectly solid state. Thus the juices become concrete and coloured; as that of the heads of poppies forms opium; from the white and very liquid state in which it formerly was, it becomes reddish-brown and solid. The same happens with the juice of aloes and of euphorbium. It is not, however, as has been believed, the mere evaporation of the water which produces this effect; and it is not a simple inspissation which takes place even without the contact of the air. Some of the principles have already re-acted upon each other; already has the equilibrium of the vegetable composition undergone some derangements, and a small portion of the hydrogen having escaped with the water, the matter is a little more carbonated, and consequently a little more coloured than it was before.

3. The

3. The solid and fresh parts of vegetables, when we wish to dry them, to deprive them of the water of their green state, which would produce an alteration in them, and to preserve them afterwards without alteration in this state of dryness, undergo something similar, whether we leave their desiccation to be effected by the rays of the sun in a convenient season and weather, or effect it by the artificial heat of stoves. The following are the changes that take place in the delicate texture of the flowers, the more solid texture of the leaves, the still more solid substance of the bark, the stalks or the roots. Their colour changes, or if it be preserved in the most permanent, it becomes deeper, and is sensibly altered; their organization is destroyed; in proportion as their water is dissipated, a more or less perceptible odorous matter escapes from them in streams that are invisible, but very discoverable; animals avoid or seek it, according to its nature; and the air is frequently altered by it. If the desiccation be too violent or too long continued, the vegetable matter not only becomes inodorous, brown or yellow, dry and brittle, and frequently little or not at all sapid, but after examining it, we find it almost burned, and very much altered; sometimes even it is no longer fit for the purposes for which it was destined.

4. Distillation on the water bath produces a change very different from that which has hitherto been attributed to it: undoubtedly it disengages

gages the water that exists ready formed in the vegetables, and reduces it to the state of vapour; but it is not only this water contained and existing ready formed which is raised, but a certain portion is also formed by the tendency which the hydrogen has to insulate itself with the oxygen. The carbon, which soon predominates, gives a fallow or light-brown colour to the vegetable substance. It is true that the gentle temperature, which this mode of treatment produces, affords only a very small quantity of this product; but this is sufficient to induce a sensible change in the organic matter, which, after it has experienced it, is no longer exactly the same as it was before. Together with this water, partly contained, and partly formed by the distillation on the water bath, an odorous matter is sublimed, which was long considered at a particular vegetable principle, and designated by the names of *spiritus rector* or *aroma*; but I have proved by particular investigations, of which I shall give an account in the article concerning vegetable transpiration, that there exists no aromatic principle properly so called; that every substance, whatever it may be, has a determinate odour when it is volatilized; that whatever escapes in vapour from the substances which are subjected to the action of the fire, presents itself with this odorous character; that it is most frequently volatile oil, dissolved in water, which constitutes it, but that it

may

may also be a small quantity of extractive matter, mucilage, or some gaseous substance.

5. I have distinguished, as a particular phenomenon or product of fire, the coction or baking of vegetables, as the chemists have not yet paid sufficient attention to this singular change, which however is one of the most known and most useful to mankind. It is known that when we expose to a dry heat continued for a longer or shorter space of time, either immediately upon the fire of the grate, or in the hot ashes, a vegetable substance, solid and generally a little succulent, a pulpy, parenchymatous fruit, a stalk, or a tuberous root; these substances, penetrated with caloric, grow tender, soft, more easy to be bruised than they were before, acquire a mild and sometimes saccharine taste, instead of the insipid or even austere flavour which they had at first, and are afterwards much more agreeable, as an aliment, to man, and even to several animals, whilst at the same time they become more easy of digestion. Is it not therefore evident, even to one who has least studied this part of natural philosophy, that a remarkable change must take place in the vegetable substance thus baked and become pulpy, soft, and sweet; that there has been formed in it water and saccharine matter by a new combination of its principles, and that coction is one of those transitions of composition which approach greatly to the nature of maturation or of germination?

As

As to the roasting of some other dry vegetable substances, an operation which is also sometimes called baking, such as that of the farinaceous grains, chestnuts, farina, fecula, bread, it is very evident that the reddish colour, the brittle property, and the somewhat acrid taste which these substances acquire, are the product of a more profound and more violent alteration which they undergo, and which in some measure resembles what takes place at the commencement of destructive distillation with the naked fire of which I am about to speak. The roasting of coffee is the first term of alteration which a dry vegetable matter can undergo, previous to its total decomposition, in the economical operations to which vegetables in common use are subjected.

6. When we expose a dry vegetable substance to a heat above that of boiling water, in close vessels, in an apparatus composed of a retort of stone-ware, of iron, or of hard glass, and coated with lute in order that it may be able to resist the action of the fire, a receiver of glass, provided with a tube of safety, and terminated by a tube immersed under a glass jar filled with water; and if we apply to this apparatus a graduated heat till the bottom of the retort has become red hot; the vegetable matter will be then entirely decomposed, by its insulated principles acting upon one another; we obtain a succession of gaseous, liquid or even solid products, which did not exist in the substance, and there remains

mains a coal retaining the primitive form, and even organization, if the substance was solid, or more voluminous and differently configured if the matter was fusible. Though these products differ more or less from each other, according to the diversity of the vegetable substances which furnish them, and though it is necessary well to distinguish the products of the gums, for example, from those of the oils, the extracts, the woods, as I shall show in the following order of this section, there exists nevertheless, even in the midst of this diversity, an identic generality of alteration, which depends upon the nature of vegetable composition, and ought to be here considered in its aggregate as a characteristic property of this genus of compounds. The manner in which the pneumatic doctrine has arrived at the knowledge of the nature and cause of this attraction is one of the most beautiful results of the revolution of chemistry, and one of the most ingenious theories which at the present day we possess. It explains all that was obscure and uncertain in the operations of the chemists: it shows how they were led into error; how the new materials that were obtained were formed; how, even from the formation itself of these materials, we may derive a sufficiently exact knowledge of the nature and primitive composition of vegetable substances.

7. In order to comprehend the remarkable changes produced upon vegetable substances

stances by the action of a violent fire, it is necessary we should recollect that these substances are composed of three primitive principles, hydrogen, carbon, and oxygen, maintaining themselves in their equilibrium of ternary combination at the ordinary temperature, on account of the equality of attraction which exists between them. But when the temperature is raised, when the caloric, penetrating the mass of this compound, removes the molecules farther from each other, then the attraction which keeps them united is weakened, and they tend to separate from one another; and if the heat be but a little superior to that of boiling water, the hydrogen and oxygen separated in part from the carbon combine together and form water, which is disengaged; a portion of the hydrogen combines with a certain quantity of carbon, and forms an oily compound, which is volatilized: thus the phlegm and the oil, the two first products of a vegetable substance distilled by a degree of heat superior to that of boiling water, were not contained ready formed in the substance, but are to be considered as productions of the fire. At the same time when these two compounds are formed, several vegetable acids are also formed, which likewise did not exist in the vegetable substance, but are owing to the combination of a portion of carbon, of hydrogen, and of oxygen in particular proportions; the pyromucous and the pyroligneous acids are the best known of these empyreumatic acids,

acids, though there is reason to believe that there are several others hitherto unknown, which are composed in this manner by the action of the force. In proportion as these new combinations are effected at the temperature which I have indicated, carbon is left behind, which not being able to enter into these combinations on account of its superabundance with relation to the hydrogen and oxygen, retains some of the fixed substances, especially of the salts and earths contained in the same organic substance, absorbs a portion of oxygen, and forms a coal which remains in the retort.

8. But when we apply to the vegetable substances a heat much superior to that of boiling water, and such as to render the retort red hot; water is then no longer formed; because at this temperature the carbon having a stronger attraction for the oxygen than the hydrogen has, carbonic acid is sooner produced; and the portion of water which was formed previous to the application of this violent heat is decomposed during this second period by the red-hot carbon, and forms carbonic acid: the hydrogen being then set at liberty is disengaged, fused by the caloric into elastic fluid, in the state of carbonated hydrogen gas; oil likewise is then no longer formed, and that which had been formed and had remained in the vegetable substance is decomposed. This is what happens at the end of the distillation of vegetables in the retort, and is the reason why

at this period, the temperature being much elevated, a considerable swelling takes place in such of these substances as are fusible. The abundant disengagement of carbonic acid and carbonated hydrogen gas then raises the whole mass, and fills the receivers with a grey smoke, on account of the portion of carbon which the latter very hot gas carries with it, and of which it begins to deposit a portion in the upper part of the apparatus, from the first degree of refrigeration which it then experiences. The action of the fire does not cease till there is no longer any hydrogen or oxygen in the substance subjected to distillation, and then the coal which is its residuum remains alone and without any volatile matter.

9. According to the rapidity and the force of the heat which is employed in this operation, we obtain at pleasure either the one or the other of the two kinds of phenomena and products, which, in fact, depend upon the difference of temperature with which this distillation of a vegetable substance is effected. The first kind of phenomenon is characterized by the formation of water, of oil and of the liquid acids; the second by the disengagement of carbonic acid gas and carbonated hydrogen gas. We have it in our power to decompose or alter the organic matter in either manner, to change it into either of the new compounds: and thus by the diversity of alteration which is in our power, it

it is very well shown in what the action of fire upon vegetables really consists.

10. I do not here speak of that product of distillation by naked fire, or the violent decomposition, effected by heat, which is obtained much more rarely and much less constantly than the preceding, from only some vegetable substances, because it is only a kind of accessory of the first, and because this product, which is constant in the distillation of animal substances, is formed only in the distillation of those vegetable substances, which approach to the nature of the former: this product is ammonia. It is observed only in such of these substances as contain azote amongst their principles, and which, by this addition, become complicated in such a manner, that they have long been termed *vegeto-animal* substances by the chemists; of these we shall speak in the following section:

ARTICLE III.

Of the chemical properties of vegetable substances treated by the air.

1. IT was impossible for chemists to comprehend or explain the effects of the air upon the vegetable substances that are exposed to it, after having ceased to live or vegetate, at the time when they knew neither the constitution of the air nor the general composition of these substances.

stances. Though they were able to observe some of the alterations which they undergo, especially the most prominent and remarkable, they were unable either to ascertain exactly in what they consisted, namely the real changes that had taken place in the composition of these substances, or to determine the part which the contact of the air had in them. They saw that the vegetable substances became coloured, dried, and withered, or were decomposed, when these effects were sufficiently marked to be very manifest and distinguishable; but they neither knew whether the same phenomena took place in close vessels, nor why or how the atmosphere contributed to their production. Moreover, when we compare the few notions which the Ancient Chemists possessed relative to this subject, even concerning the most violent of these alterations, we soon see that most of the facts which concern them escaped their notice, and that it was even very natural that they should hardly pay any attention to them: accordingly, prior to the establishment of the pneumatic doctrine, before the data of Lavoisier and Citizen Berthollet, nothing had been said concerning the properties of the vegetable substances dependant upon the air. The elementary books, written even since that period, have treated too superficially concerning this subject.

2. In order that I may omit nothing that belongs to these chemical properties derived from the action of the air upon the vegetable sub-

substances, I shall describe them, or rather I shall announce them here as forming six very distinct phenomena.

a. The object of the first will be the absorption of a principle of the air by these substances.

b. That of the second, the precipitation and the concretion in the vegetable liquids which follow this absorption of one of the principles of the atmosphere.

c. The third will comprehend the coloration which these substances undergo.

d. The fourth, the kind of combustion to which we may refer this chemical property in general.

e. The subject of the fifth phenomenon will be the change which the air itself experiences from the action of the vegetable substances, in proportion as its contact causes them to experience the four first.

f. Lastly, in the sixth and last phenomenon, I shall rank that kind of decomposition, more or less slow, which vegetable substances undergo by the contact of the atmospherical air.

This division into six phenomena, by particularly fixing the attention of chemists upon each species of alteration which the air produces in the vegetable compounds, will be attended with the particular advantage of omitting nothing which is essential to be known respecting this genus of chemical properties; and though this department is not so far advanced as were to be wished,

wished, it will at least appear very proper for exciting the attention of the learned, and engaging them to study, more than they have done hitherto, this kind of action, which deserves to occupy them, and form the object of more profound researches than those to which it has yet given occasion.

3. It is a fact well known in the immense series of pneumatic experiments which have been made during more than twenty years past, that when we expose a substance, and especially a vegetable liquid to the contact of the air, in a vessel which serves exactly to measure its volume, and also enables us to examine the alteration which the air has experienced, a more or less sensible absorption takes place, or diminution of volume more or less distinguishable. When we examine, by eudiometric means, what part of the air has been absorbed, we find that it is oxygen gas, and that what remains of the air is more or less mephitic, more or less surcharged with azotic gas. Almost all the vegetable liquids possess this property; but it is more remarkable in some, such as the saps, the juices of herbs, the oils, the extracts dissolved in water, &c. some vegetable liquids effect it even in so powerful a manner, that they become very frothy by agitation. We must take care not to confound those which become frothy in consequence of a gas which is disengaged from them, with those that become covered with a frothy scum in consequence of the absorption. The

first present this phenomenon without the contact of the air; the second produce a vacuum in vessels partly full, in which these liquids are agitated; it is probable even that we may hereafter find some vegetable substances that have a sufficient avidity for the atmospheric oxygen to act eudiometrically upon the air.

4. In proportion as the liquid or dissolved vegetable substances that are exposed to the air absorb oxygen from it, they become turbid, deposit flakes which are precipitated, or become covered with concrete plates of which they did not previously exhibit the slightest trace. In this manner the oils concrete at their surface, or even in their interior part, by the absorption of the oxygen, as has been discovered and well proved by Citizen Berthollet. In this manner, I have discovered that the expressed and clarified juices, when exposed for some time to the air, become filled with concrete flakes which swim in their liquor, and which are deposited after some hours; which does not happen to them in well-dressed and full vessels; there are even some decoctions of dry vegetable substances, of woods, barks, and roots, which become turbid by the contact of the air, and which afterwards deposit powders, or thick and ropy insoluble masses, or irregular flakes. I have particularly observed that much of this matter was formed in the decoctions of Peruvian bark that were made to boil for a long time, and that they thus lost the greater part of their virtues

tues. It is therefore one of the well characterized chemical properties of vegetable substances, to be rendered in this manner concrete by the atmospherical oxygen which they absorb, and to form oxygenated products, which precipitate themselves from the liquids, and which have become insoluble, or much less soluble than they were before.

5. The coloration of vegetables by the air is one of the most known and most constant phenomena; every one indeed knows that the white roots of falfis, the white petioles of the Spanish thistle, beet, the husks of nuts, the pulp of pippin-fruits, &c. when exposed for some time to the air, assume yellow, brown, and even black colours, against which, attempts are even made to guard them, in order to preserve that whiteness which is agreeable in alimentary substances. The colours which some kinds of white wines so rapidly assume in bottles, also afford a frequent proof of the existence of this coloration; to this we may add the coloration of the skins of fruits, that of the leaves which acquire a deep green colour, of the barks which become brown, of the flowers which do not acquire their tints till after they are blown, and which, having been almost colourless in the calicine covering in which they were folded up, become adorned with all their colours when they open in the atmosphere; but these phenomena being complicated with those of vegetation, during which they take place, I

ought here to mention those only which belong to vegetable substances when deprived of life. I have studied with attention, and described in "Annales de Chimie, tome V," the influence of the atmospherical oxygen gas upon the coloration of vegetables, Having been struck with the beautiful blue colour which indigo assumes in the air, after having been taken green out of the dyeing-vats, with the blackness which substances impregnated with galls and which ink assume in the air, with the brilliant or deep colours which all the cryptogamic plants exhibit when they are altered or decomposed in the atmosphere, with all that takes place in calico-printing and dyeing, with respect to the use which is made of vegetable substances in those arts, as well as with the phenomena of coloration which I have just quoted in the different parts of living plants, I particularly directed my researches to the infusions and decoctions, and especially those of the barks of the yellow or red woods. I observed, that when exposed to the air, they become covered with a granulated pellicle, which passed successively through the colours of brown-black, brown-purple, chestnut-red, orange and yellow; that in the latter state, the coloration by the air was fixed, and becomes little or not at all alterable; that previous to the coloration in yellow or fawn, which is the last term, the vegetable matter passed through different tinges which remained stationary and fixed, according to the different

ferent proportions of oxygen. I have proved that these shades were really owing to the fixation of oxygen, by imitating them by the addition of different proportions of oxygenated muriatic acid to these decoctions: I particularly obtained from the decoction of Péruvian bark five or six colours more beautiful, more rich, and especially more solid than the ordinary lakes, of which I shall speak hereafter. From the whole of my labours upon this subject, I have drawn the following general results: *a.* Oxygen combined with the vegetable substances changes their colour; *b.* the proportions of this principle produce variations in the shades; *c.* these shades follow a kind of degradation from the deepest to the lightest colour; *d.* the vegetable reds, purples, violets, chefnuts, blues, owe their tinges to different proportions of oxygen; *e.* the complete saturation with this principle produces the yellow, or the fawn, which is the most durable of all the vegetable colours; *f.* the change of colour by the absorption of the oxygen is followed by a change of nature, and the vegetable substances which experience it become less soluble in water, and more or less oily or resinous.

6. Besides the concretion and coloration which are observed in vegetable substances exposed to the air, and which are owing to the fixation of a more or less considerable proportion of atmospheric oxygen; these substances undergo a slow combustion and an alteration in their composition,

composition, which has been very well determined by the experiments of Citizen Berthollet. At the low temperatures to which vegetable substances are exposed in this kind of experiments, hydrogen has more attraction for the oxygen than carbon has: accordingly, the hydrogen, a principle of these substances, tends to disengage itself from them, and is actually separated, molecule after molecule, in such a manner as to burn by degrees with the atmospheric oxygen, and to form water: hence the drops of this liquid, which appear upon the sides of the receivers, in which we thus expose in considerable volumes of air the sliced fruits and the chips of wood, whose alterability by the air we wish to determine. In proportion as this hydrogen exhales and burns slowly in the air, the quantity of carbon, which forms one of their principles, augments and colours the vegetable substance the more sensibly, the more considerable this augmentation is. This is the manner in which Citizen Berthollet has explained the brown colour which woods assume by their exposure to the air. This effect is well known in the wood of the oak, and in that of the walnut-tree: it is still more remarkable in mahogany, which from a delicate rose or pale flesh-colour passes to a blackish brown: it is known that this alteration, the product of a slow combustion of the hydrogen and separation of the carbon, takes place only at the surface, since whenever we remove or uncover this surface,

we find a much less deep colour, which indeed must in its turn assume the above-mentioned cast, when it shall have been left for some time exposed to the air.

7. It is also of essential consequence, in order to appreciate what happens to vegetable matters during the changes which they experience by the contact of the air, to determine at the same time the change which the air itself experiences, and this determination must equally lead to the knowledge of what happens in these substances, or the real nature of their chemical properties. Air, which has been left for some time in contact with the vegetable substances, is found deprived of a part of its oxygen, which is determined by the eudiometric processes. It even occurs pretty often in the circumstances of common life, that it is not necessary to have recourse to eudiometrical processes in order to perceive this alteration which air experiences from the action of vegetables. Close places, in which these substances are accumulated, constantly become dangerous to animals; persons have often been known to have been struck with asphyxia in confined or close places, where a large quantity of flowers, leaves, or stalks were drying, or where large heaps of hay or fruit were accumulated. Besides the odorant matter proceeding from the volatilization of some of the principles of the plants, or of their parts, the frequently pernicious alteration of the air shows itself here under three aspects, or produced
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by three causes acting at the same time. The one is the absorption of a portion of its oxygen, of which I have already spoken; the other consists in the combustion of the hydrogen, which I have developed in the preceding number; and the third, of which I must also speak a word here, must be referred to the formation of a certain quantity of carbonic acid gas. This, the influence and the quantity of which may be determined by the fixed alkalis and lime-water, shows that hydrogen is not the only combustible principle disengaged from the vegetable substances by their exposure to the air; that whilst it exhales from these substances it carries with it a small quantity of carbon, which being extremely divided by this æriform solution, burns, either at the same time as the hydrogen, or immediately afterwards, as takes place in the lungs of animals. Thus the air, at the last term of its alteration by dead vegetable substances, may be entirely deprived of its oxygen; contain a large proportion of water, the greater part of which, not being able to be held in solution, is precipitated; become charged with a portion of the vegetable matter in the state of vapour, which gives it a smell more or less strong of carbonic acid; present even a temperature more elevated than the atmosphere, by the double condensation which its oxygen gas experiences, both by uniting with the hydrogen, and by combining with the carbon. Thus these different effects, so well appreciated by the pneu-
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matic doctrine, throw the greatest light upon the alterations of vegetable substances by the air.

8. Every one knows that besides the five effects, or rather besides the series of different alterations which I have just explained, and which characterize the chemical properties of the vegetable substances with respect to the action which the air exercises upon them, or which they exercise upon the air, they are at last decomposed more or less slowly and completely; they undergo a kind of analysis, which separates from them by degrees all the volatile principles, and collects their fixed elements in the form of an earthy residue, or rather one of an earthy appearance; that in this manner, Nature employing the air at once as a reservoir and an instrument, destroys, with the aid of time, the most solid texture of ancient trees, as well as the most frail and delicate fabrics of annual plants; that she restores to the general circulation of beings the principles which she had lent for some time to these organized bodies. But as this effect of spontaneous analysis, of natural and slow decomposition, is complicated of the actions of caloric and water with that of the air, as it gives rise to different and very important results that are to be considered in particular; and lastly, as it deserves to be comprehended and treated more particularly in this section, in the order of facts which shall follow that devoted to the examination of the immediate materials of plants,

plants, I shall here only announce it, in order to render more methodical and more complete this outline of the alterations which vegetable substances undergo, or the chemical properties which they present by the action and the contact of the air. I shall reconsider and explain it in a more ample manner, in the fifth order of this section, devoted to the examination of the alterations of which the vegetable compounds are spontaneously susceptible.

ARTICLE IV.

Of the chemical properties of vegetable substances treated by water.

1. **THOUGH** I have already considered water as a means of analysis, acting upon vegetable substances, and serving to separate from them some of the materials of which they are constituted, though I have already remarked that it may be employed as an instrument in five different manners, by tranquil maceration, by agitated maceration, by infusion, by digestion, and by decoction, means to which we may also add that of distillation, I have not yet proceeded to examine with due attention the changes, or the chemical properties which these substances are capable of experiencing from the action of water, but merely the general effect
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of this agent and the influence which it may have upon the separation of the principles of plants.

2. In this place another view presents itself, another kind of consideration, not less important and much more profound than that which related to the vegetable analysis in general. It is necessary that we should determine, with precision, all the effects which water produces upon the vegetable compounds, the different alterations which it causes them to experience, and afterwards the chemical properties which it exhibits in them. By approximating all the phenomena which water, employed in the different processes above indicated, produces in vegetables, by comparing together all the different effects which result from thence in their composition, I find that they may be reduced to eight, which are very distinct, and which must be examined in particular, in order to appreciate their relation to the chemical properties of these organized bodies.

3. These eight phenomena seem to follow each other in the order and according to the disposition which I am about to lay down.

- a.* Absorption and softening.
- b.* Mechanical separation of the parts.
- c.* The fusion or infulation of some of the immediate materials.
- d.* The solution of some others.

e. The

e. The new union or the mixture of such of these immediate principles as are dissolved at the same time.

f. The alteration which they undergo either by the action of the water, or by that which they naturally exert upon each other.

g. The coction, or the complicated effect of the boiling of the vegetables in water.

h. Finally, the total decomposition, which is the termination of the action of the water, and the ultimate term of the chemical properties which the vegetable substances present by its influence.

It is, however, necessary to remark that these phenomena are not always produced by the action of water upon these vegetable substances; that caloric has more or less influence upon them, according to the temperature to which we elevate the water we employ; that since, even when we take cold but liquid water, it contains an abundant proportion of this principle, it is evident, that it always enters for something into this action.

4. The first effect of water is known to every one, and takes place in every vegetable matter which is impregnated with this liquid, which is kept immersed in it, or which is even placed in the air when water is precipitated from it; this matter absorbs it, becomes penetrated with it, admits it from all sides between its laminae, its layers, its fibres, or its molecules; these are then removed from each other and swell; whence results an augmentation of volume, a change of form,

an enlargement which are made use of in many of the arts, and which, as is well known, answer many useful purposes. This effect is not merely that of suction and of the capillary tubes, as has been asserted by natural Philosophers in their mechanical explanations; it would in that case have no relation with chemistry, and would not deserve to be enumerated amongst the properties which this science ought to examine in vegetables. It is not confined to a mere physical power; it follows the laws of chemical attractions, and on this account the vegetable substances differ even in the manner in which they absorb water, in which they are penetrated by it, in the quantity which they absorb of it, in the degree of augmentation of volume which they experience from it, and especially in the adhesion which they contract with it. Accordingly, different woods steeped in water for the same space of time, augment differently in weight and volume, and dry afterwards with different phenomena.

5. When the vegetable substances have remained for some time immersed in water, those whose texture is the most delicate, are not only penetrated with the largest quantity of this liquid, but experience also, by the effect of the removal of their laminæ or fibres from each other, a separation, a kind of dissection, which detaches filaments from them, so that these are precipitated or deposited at the bottom of the liquid, the transparency of which

which they impair by remaining for some time suspended in it. From this action, which also depends upon the affinity of the vegetable molecules with those of the water, there results a disorganization of the former, soon followed by a more decided alteration, a more intimate decomposition or change of nature, of which the first separation has been the source. It is not only in the furfuraceous form or in laminæ, leaves or filaments, that the water thus detaches, by long contact, the different materials of the vegetables; frequently, this separation, which takes place in consequence of the different attraction of the immediate materials of the plants for the liquid, presents, as it is effected, soft, pulpy, mucous, flaky, gelatinous substances, which float in the liquid, or which are deposited in different layers, but this separation is then accompanied with a considerable alteration of the same materials, and belongs to one of the subsequent effects.

6. When we employ water considerably heated for treating vegetables, the elevated, and especially the continued temperature assisting the action of the water, causes it to penetrate more deeply into the parenchyma and the organic texture of the plants; and this liquid, having become more active, divides, softens, and entirely fuses such of the immediate materials as are susceptible of this change of state; so that without combining with the water, which even repells their union, these materials are nevertheless,

theless, insulated from the vegetable, and present themselves alone with the properties which characterize them. Thus when we boil roots or barks for a long time in water, we see at the surface of the liquor drops of oil, which float without mixing with the liquid. Resin, Gum-resin, and several other immediate materials of vegetables are affected in the same manner, and the separation of these materials contributes to the analysis of the plants, or of the parts of plants which are subjected to it.

7. At the same time that these three effects of water take place, or after they have taken place, this liquid takes up from the vegetables such of the materials as are soluble in it, and accordingly as these are more or less numerous, or more or less abundant, the water takes up a different proportion, and favours the separation or the analysis of these materials: these then partake of the liquidity of the water, and cannot be separated from it except by evaporation; and it is always with the sole and almost exclusive intention of thus dissolving some of the immediate materials of plants, that water is employed in their analysis; but it is necessary to add to what I have already said upon this subject, that the different soluble materials of these bodies are so in different degrees, and vary according to the more or less soluble texture to which they belong, according to the age of the plants, and according to the particular state of these

these materials. Some of them, and we shall see that to this class belong the mucilages, the extracts, the vegetable salts, &c. are very soluble in the cold, and in small quantities of water; others require a heat more or less intense, and also a larger quantity of this liquid to dissolve them; whence it follows, that, according even to the variability of this chemical property in the plants, or the vegetable matters of whatever kind which we examine, we ought to treat them differently with respect to the proportion and the temperature of the water which we employ, as a first trial will sufficiently indicate.

8. It is not to the mere loss of these materials soluble in water that vegetables are limited, under this point of view, as to their chemical properties indicated by the action of water; there takes place also during and by the act itself of this solution, another effect equally necessary and important to be appreciated, in order to acquire a knowledge of these properties; when two, and still more so when more than two of these soluble materials pass thus from the vegetables into the water, this fluid combines and unites them in another order and under another form than that in which they existed in the natural substance whence it has taken them: so that it must not be concluded from this experiment when employed as a means of analysis, that these matters, so dissolved and afterwards found again in the water, existed in the same state, and in
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some respect under the same association in the vegetables that has been analyzed. Thus the sugar, the gum, and the essential salt which are found dissolved at the same time in the water, and which adhere to each other, after having been artificially separated from it, were not combined three and three in the same manner in the vegetables from which they proceed; and in like manner the materials that have not been touched by the water, but which have escaped its solvent action whilst the former were dissolved in it, are applied and united to each other in a different manner than they were when they formed integrant parts of the texture and of the parts of plants.

9. The consequence of this alterative and combinatory action which water exerts upon the vegetable substances which it dissolves, as also upon those which it leaves undissolved when it is brought to act upon plants, is necessarily a change of nature, an alteration of some kind, especially between the dissolved substances which must re-act upon each other, and become different from what they were at first. This is a result which must well be kept in mind in the vegetable analysis, which, without the condition here proposed, would lead us to commit many errors. I have shown in the preceding article, that the air has great influence upon the state of vegetable compounds dissolved in water, upon the product of the infusions and the decoctions: there are

therefore here, with respect to the chemical properties of the vegetable substances, three effects, which become complicated by being associated with each other; the one is the action of the water itself upon the substance dissolved; the second is the combination of several of these substances dissolved at the same time; and the third is the influence of the air upon this matter held in solution; whence it follows that it is not every action of water upon a vegetable that furnishes exactly and without any alteration, the substances this liquid takes away from it; and this depends upon the great alterability of these substances, the slight equilibrium which keeps their first principles combined, and the facility with which it may be broken.

10. A great part of the phenomena which I have just enunciated in their generality, are united in the operation so familiar to mankind, when they boil plants in water, in order to render their vegetable aliment better tasted, more tender, and more easy of digestion. It is well known what a great difference there is in the taste, softness, and agreeableness in general, between vegetables boiled in water and baked vegetables, of which I have spoken in one of the preceding articles. It is known that the change produced by this boiling is owing to the presence of water which penetrates them, makes them tender, softens them, dissolves some of their principles, changes more or less their nature and their properties, converts for example the

the harsh juices into mild matter, and the insipid matter into saccharine substance. It is therefore very evident that this change is owing to an union of the different alterations of which I have spoken in the preceding numbers, and that, if we well conceive the nature of these alterations, it will not be difficult to comprehend perfectly the boiling of the vegetables in water; an operation the phenomena and the result of which chemists have not sufficiently determined. They have not determined, for example, why water, holding a small quantity of earthy salts in solution does not effect this boiling; which appears to depend upon the circumstance that the water, being saturated with these salts, and especially with the sulphate of lime, is no longer able to dissolve the vegetable matter, which, in this softened state, constitutes the boiling of plants. Sufficient attention has not been paid to the very useful power of the vapour of water in boiling pulse, grains, and fruits, which is employed with so great advantage, especially with respect to hard, raw, and saline water, and may serve in certain countries or at sea for this important purpose, because the action of the fire reduces only the pure water into vapour which acts upon the vegetable substances.

11. Water, like caloric and air, has the power of completely decomposing the vegetable compound, and entirely separating its principles. This is a fact which is proved by a thousand

circumstances, and especially by that which is so frequently and so abundantly exemplified before our eyes in the immersion of vegetables in this liquid. We see at every moment the plants plunged in this liquid become completely destroyed in it; they become soft, pulpy, and are reduced into a kind of ropy and putrid mucilage, which quickly disappears. This phenomenon varies in the woods, which first become black in it, and afterwards brittle. It is very remarkable in the stalks of hemp and flax, which, by remaining too long in the water of the steeping-vessels, or by too long steeping, are burned, become black, putrefy and entirely lose their consistence. In chemical experiments, as well as in the operations of nature, every vegetable solution is gradually decomposed and destroyed; but these effects are owing to a complication of causes and of actions, and also present a series of important differences or modifications, which it is essentially necessary to examine in the most detailed manner, and which I reserve for the fifth order of facts relative to the alterations of which vegetables are susceptible. Our present object is merely to describe in general the complete decomposition effected by water, and to explain it as the last term of the chemical properties and actions which the vegetable substance can present under the influence of this liquid.

12. It results from these eight phenomena appertaining to the re-action of water upon vegetable substances, that most of them consist
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in a series of actions, which, like those of the air and of fire, tend really to insulate the constituent principles of these substances, to change their nature, to extract them, or to reduce them to the state of two or three binary compounds, or even to their primitive elements; and that this series of actions causes the vegetable compound to pass through successive modifications, which frequently resemble those which it experiences in nature, and even in the vessels of the living plants; which proves that the general progress of this decomposition is uniform, and obeys constant and determinate laws.

ARTICLE V.

Of the Chemical Properties of Vegetable Substances treated by the Earths and the Alkalis.

1. IF we except some very well-known combinations between the alkalis and certain immediate materials of vegetables, such as those between the oils and those bases which constitute the soaps, scarcely any thing has hitherto been said concerning the reciprocal action between those two kinds of substances; and nevertheless it is not to be doubted that they have a more
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or less energetic tendency towards each other. The well-known energy which the caustic fixed alkalis exert upon organic substances in general, is too great and too powerful for it not to be exercised in some manner upon the vegetable substances : it is therefore of importance to attempt at least to supply, by some general consideration, and by the collection of some facts, the almost total silence of chemists with respect to this subject.

2. The dry earths, filex and alumine, produce no very sensible alteration upon vegetable substances: it is well known, that when immersed in pure and well-dried sand, they keep without alteration. Besides the advantageous use to which this kind of inhumation is applied, in rural and domestic economy, in order to preserve roots and pulse without change guarded against the moisture, the atmospheric variations, and the process of germination, when the precaution is used of placing them in a depth at which the temperature is not subject to variation; we also know that industrious art which preserves with a kind of freshness, and even with their most exact forms and more tender tints, plants of a delicate texture, by sprinkling and surrounding them with fine and dry sand, in vessels to the middle of which they are fixed and suspended in their natural situation. Thus filex has in some sort the power of preserving the properties, the organization, and the composition

position of vegetables ; it prevents their alteration and spontaneous analysis ; it checks their septic decomposition.

3. The same is not the case with alumine : always more or less humid, or retaining between its molecules a certain proportion of water, argil does not serve in the same manner for the preservation of vegetable substances ; accordingly they become altered, and putrefy when surrounded with or buried in it. This kind of alteration, which is considerably rapid even with wood buried in the argillaceous earths, is entirely owing to the water which they retain ; and it is only because this species of earth is always moist and soft, the vegetables experience in it this decomposition, of which, as we see, the alumine is the occasional cause. This earthy base unites pretty easily with certain vegetable substances, with the mucilages and the oils ; but this effect belongs to the history of the immediate materials of which I shall treat elsewhere.

4. The alkaline and acrid earths, barites, strontian and lime, are very analogous to the alkalis strictly so called with respect to their action upon vegetable compounds. They powerfully absorb the water with which they are impregnated ; they dry them, and even effect upon them a kind of semi-combustion, by the heat which they produce in seizing the water which is contained in them. There are even some of the immediate materials of plants upon which they exert an action of combination, as

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I shall shew hereafter. Magnesia, which is frequently prescribed by the physicians, in its mixture with vegetable powders, favours the solution and extraction of some of their principles; but this action has not yet been examined or determined with sufficient accuracy to enable me to say more concerning it in this place.

5 I shall not here speak of the combination so well known under the name of soap, which takes place between the fixed alkalis and the vegetable oils, nor of the action of these bases upon the colorant parts: this subject belongs entirely to the history of the immediate materials of vegetables, with which it is not yet time for me to occupy myself. I shall only enunciate some generalities relative to the manner in which we may conceive the properties which the vegetable compound presents, when it is subjected to the action of the pure and powerful alkalis, whether in the solid or in the liquid form. These bases, which are so energetic and so greedy of moisture, quickly take away that which is contained in the vegetables. But their action is not limited, like that of the acrid earths, to a simple desiccation. When we triturate them dry with the substances, they effect a profound alteration in their texture, their organization, and their composition. They soften them, frequently reduce them into a soft pulp, colour them, and decompose them. The same effect takes place, but in a less powerful

ful degree, with the caustic dissolved alkalis, especially when their solution is dense and concentrated: then, even without the aid of heat, which however greatly augments their activity, they powerfully dissolve the vegetable substances, and bring them into a kind of saponaceous state. It is in this manner that unsized paper assumes the form of pulp, runs quickly into holes or becomes dissolved, when we employ it to filtrate alkaline leys. It is in the same manner that linen, employed for the same purpose, loses its strength and part of its weight; an inconvenience which is perceived even in the domestic operations of washing and bleaching, when too strong leys are employed. There are some vegetable substances, such as approach to the animal substances by the azote which they contain, which, like the latter, yield ammonia at the moment when they are triturated with solid alkalis. This phenomenon I shall explain more at length when treating of the immediate materials of vegetables in the subsequent orders. The caustic alkalis, by the avidity with which they tend to unite with water, effect the decomposition of some vegetable substances by insulating their oxygen and their hydrogen. This action resembles that of the acids.

6. The properties which the vegetable compounds present in the action which they are susceptible of experiencing from ammonia, approach but slightly to those which I have just described relative to the fixed alkalis: they have

have an analogy, which may be easily conceived from the comparative nature of these salifiable bases. But the weakness of this species of volatile alkali explains how ammonia has only in a few circumstances even a slight solvent action upon these compounds. It favours, still less than pot-ash and soda, the solubility of some of these compounds in water, and it changes their nature but very little.

ARTICLE VI.

Of the Chemical Properties of the Vegetable Substances treated by the Acids.

1. **THOUGH** chemists have long employed the acids for the purpose of examining vegetable substances, and though they have obtained some advantage from them with respect to the knowledge of their properties, it is only since the great discovery of Bergman, of the conversion of sugar into a peculiar acid by means of that of nitre, that this kind of vegetable analysis has become a means of the greatest importance for appreciating the chemical properties of these compounds. The pneumatic doctrine has especially thrown the greatest light upon this decomposing action of the acids; this alone has been able accurately to appreciate its existence, to
determine

determine its causes, to verify its results, and well to distinguish all its phenomena. It may even be said, that between the discoveries of Bergman and Scheele, the two first chemists who have indicated the change of the vegetable compounds by the nitric acid, and the ingenious explanations founded upon other discoveries of the French pneumatic doctrine, the distance and the interval for the progress of the human understanding, is greater than between the ancient state of chemistry and the first observations of the two Swedish chemists. No part of the science has made a more striking progress, nor has arrived at more beautiful results than this: and though that of the action of the powerful acids upon vegetable substances has not by any means been carried so far as it evidently may hereafter, there is nevertheless no re-agent, which has more effectually contributed to the knowledge of the chemical properties of vegetables than these active instruments.

2. It is difficult to generalize the action of the very decomposable mineral acids upon vegetable substances, because this action differs more or less, according to the nature of the acid, and according to that of the organic substance. It may however be said, that it always tends to destroy these compounds, to cause them to pass through several intermediate states previous to their total decomposition, and that it especially converts them into several vegetable acids more or less energetic, more or less oxygenated,

generated, till the period when it changes them completely into water and carbonic acid; by augmenting the quantity of oxygen in general, they frequently separate part of the hydrogen or of the carbon, which they burn separately, and cause them to fly off in the form of water and carbonic acid. Thus they change the relative proportion of their first principles; they cause the nature of the vegetable composition to vary in many respects: hence the multiplied states of the products, and of the phenomena to which they give rise.

3. But notwithstanding this multiplicity of actions and of conversions produced in the vegetable compounds, by the powerful acids with simple or with unknown radicals; many which depend upon the strength of the acids, their quantity, and even the differences of the vegetable substances, and the temperature at which they are treated, we may however refer to three general modes the alterations to which these bodies give rise, or the chemical properties which the vegetable substances present when treated by the acids. Sometimes in fact they are dissolved without being sensibly changed; sometimes they experience an alteration without the acid itself having yielded oxygen, sometimes their nature is changed, or they are converted into new products, at the same time that the decomposed acid gives them a portion of its acidifying principle. In the latter case, the alteration

teration of the vegetable substance is much more profound than it can be in the two first circumstances. It is of importance to consider each of these effects.

4. In order that the powerful acids may act only as simple solvents of the vegetable substances, it is necessary, either that these acids should be very much weakened, or that the vegetable compounds of a greater or less degree of density should strongly resist their decomposition. The latter case is extremely rare, and in some sort foreign to the vegetable nature: the first is that which most frequently takes place. There is scarcely any vegetable substance which is not susceptible of being dissolved, either in the cold or by heat, by all the acids when weakened and completely saturated with water; and there is also no acid whatever, which has not the property of effecting this solution, when it is made without sensible decomposition on a portion of the vegetable substance; there is no change of colour in this substance, and no change whatever is discovered in the acid. Frequently we may separate the matter thus dissolved by means of an earth or an alkali, which seizes the acid, and forces it to quit the dissolved matter. It is then deposited almost without alteration, or at least but very slightly altered.

5. But though not altered at the moment of its solution in a weakened acid, the vegetable substance does not remain without a more or less powerful alteration when this solution is

kept. At the end of some days we find it no longer possessed of all its properties ; its nature is gradually changed ; it is decomposed, and it passes slowly with the aid of time into the state which it is susceptible of assuming in the case where the same acid, when stronger, attacks its combination quickly and powerfully. This is observed constantly in those solutions when kept for a longer or shorter space of time. They are all found changed into vegetable acids.

6. The second case of the action of the acids, which I have distinguished with respect to the different properties of which the vegetable substances are susceptible when treated by the acids, is that in which they are altered, changed, modified, without the acid itself being decomposed, without its losing or being separated from its oxygen. The second case had not yet been appreciated before Citizen Vauquelin and myself gave an account of it towards the end of the fifth year of the Republic. It takes place especially in the action of the sulphuric acid upon these substances. When we suffer these two kinds of substances to act spontaneously upon each other, when for example we mix in the cold this acid with straw or wood, &c. the vegetable substance is disorganized, softened, and as it were dissolved ; a remarkable quantity of carbon is separated from it, and it is easily seen that it is decomposed, as if it had been in part burned or heated in close vessels. Before the investigations that have been mentioned, it was believed that

that the fulphuric acid produced this effect by the separation of its oxygen. However, as no sulphureous acid is disengaged during this remarkable change, and as we find the fulphuric acid not decomposed, not disoxygenated, after it has taken place, it certainly proceeds from another cause. This is determined by examining the state of the acid; it is extremely weakened without its nature being changed; it contains a large quantity of water which it did not contain before; when it is mixed with a fresh quantity of water, it does not produce, by far, the same heat which it produced previous to this re-action. It is therefore evident that it consists in a formation of water, that the fulphuric acid, by the great tendency which it has to unite with this liquid, has solicited and effected the separation of a portion of the hydrogen and oxygen of the vegetable substance, and has consequently set its carbon free; that this alteration, of which the acid greedy of water is the occasional cause, without however relinquishing its own oxygen, has no limit, except the saturation of this acid by the water, and that it consequently passes entire into the vegetable substance. We shall see that this is the cause of the phenomenon of etherification, or the formation of ether.

7. In proportion as this decomposition of the vegetable substance by the concentrated sulphuric acid takes place, as it is converted into water and carbon, a portion passes also into the state of acid; it is almost always to the acetous acid

acid that this acidification tends: it may be obtained by distillation. We shall see hereafter that this acid is formed by the union of a given proportion of oxygen of carbon and of hydrogen; and it is evident that it is, like water, the product of a change of equilibrium in the vegetable substances. It must be remarked, that during this particular kind of alteration no effervescence takes place; no bubble of elastic fluid is separated, as in fact no principle of the vegetable or of the acid is disengaged. There is only disengaged a certain proportion of caloric by the union of the acid with the water that is formed, and in proportion to the density acquired by this combination, as well as to the precipitation of the carbon.

8. The muriatic acid acts in the same manner upon the vegetable compounds when it is concentrated, and when it is left for a long time in contact with them. The muriatic acid gas, as being very greedy of water, acts still better than the liquid and fuming muriatic acid; but the action of both is infinitely longer than that of the sulphuric acid, on account of the little activity of the muriatic acid. When we suffer a vegetable substance to remain for a long time in contact with this acid, it at last becomes colored brown, black, is softened, carbonated, and the acid is found to be extremely weak. As the decomposition of the muriatic acid has not hitherto been observed, since we knew of no circumstance in which it relinquishes oxygen, it is easy to conceive

ceive that all the effects which it produces upon vegetable substances are occasioned only by the attractions of the mass itself in all its integrity. Thus when, after long contact of some of these substances, which then approach in their nature to that of the animal substances, with the muriatic acid, we extract muriate of ammonia from the mixture, we must conclude that this alkali is formed, like the water, at the expense of the principles of the vegetable, and by the attraction which the acid exercises upon the ammonia.

9. With respect to the phenomena which vegetable substances present with the acids which are decomposed together with them, they all depend upon the separation of the oxygen from these acids, and the transfer of this principle to those of the organized substances. Accordingly, all the acids which do not adhere strongly to oxygen, and which easily suffer it to be taken from them, produce similar effects. Thus the sulphureous acid, that which of all acids acts the least upon vegetable substances, has at least the property of discolouring such of these substances as have the strongest colours, by relinquishing its oxygen to them. Thus the oxygenated muriatic acid, likewise by introducing its oxygen into the vegetable substances, not only alters their colours, bleaches them, and renders some liquid vegetable substances concrete, but at last burns these sub-

stances, reduces them to charcoal, or converts them into acids.

10. Of all the acids that of nitre changes all the properties of vegetable matters most powerfully, when it is very concentrated, and especially if it contain nitrous gas, it burns these substances with such activity that it inflames several, and reduces them to the state of charcoal. When a little weaker, it changes the colours, destroys them, or communicates to them a yellow tinge, which is unalterable or indelible. This effect of the nitric acid has long been known, but not explained: but it is evident that it is owing to the quick separation of the oxygen and the large quantity of this principle, which suddenly seizes the hydrogen of these substances, and proceeds so far as to inflame them: but it is not in this violent action that the most useful influence of this acid upon vegetable compounds consists. When studied according to the lights of the pneumatic doctrine, this influence serves at present to acquaint us with all the properties of these compounds: it is in the appreciation of these effects that the French chemistry has rendered the most striking services to Natural Philosophy, as I shall shortly show.

11. Though the action of this acid varies more or less according to the diversity of the composition of vegetable substances, and it is by examining each of the immediate materials of plants in particular, that we can appreciate all the

the different circumstances of this action, we may nevertheless deduce even from all the variations of the effects which it produces, a common mode, a generalized result, which embraces the collective whole of these variations, and which, while it serves to render them intelligible when it shall be necessary to treat of each of them, may at the same time serve to determine in what the totality of the effects which it produces upon these vegetable compounds consists, and lead us to characterize their chemical properties: it is in this manner, and without entering into the details which belong to the following order of facts, that it is essential in this place to consider the action of the nitric acid.

12. As the total tendency and the term of this action is the complete decomposition of the vegetable compounds, their reduction into water and carbonic acid, and as it proceeds more or less rapidly towards this term, when we employ strong and concentrated nitric acid; in order to understand and clearly to ascertain all the intermediate degrees of this decomposition which it is capable of effecting, we take it weakened with a certain quantity of water; for example, at 28 or 30 degrees of the ordinary areometer, and frequently it is even diluted with from half its weight to twice or thrice its quantity of water. It is left to act in the cold, or its action is favoured and made to commence by the aid of a gentle temperature, or it is rendered more violent and energetic by heating it more

strongly or for a greater length of time. In the first case, we have only a rare and slight effervescence, the product of which is nitrous gas, mixed with a small quantity of carbonic acid. In the second, the proportion of this disengagement is more considerable; and in the third, we may go so far as completely to decompose a portion of the acid: for as we employ from three to six times the weight of the vegetable matter which we wish to treat, there is always more than is required, in order to obtain the products which we seek, and the results which we expect.

13. In each of the circumstances which have just been enunciated, the products of the action of the acid differ; the stronger this is, the more in general we obtain of nitrous gas and carbonic acid gas; consequently, the more oxygen there is separated from the nitric acid, the more carbon there is taken from the vegetable substance, and burned by the oxygen. The general, or the most constant and most abundant product of this reciprocal and simultaneous decomposition, is a series of different vegetable acids; sometimes to the number of three or four, sometimes a single one, or at least only two, all composed of hydrogen, carbon, and oxygen, whose characters of composition consist in the different proportions of their three principles, and of which I shall give an account amongst the immediate materials of vegetables; for I must here observe, that that which is the
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most important and the most decisive for the pneumatic doctrine, adapted to the vegetable analysis, what most proves its strength and stability, is that the acids artificially composed by the nitric acid acting upon the gums, sugar, the leaves, the extracts, the woods, &c. are perfectly similar both in their properties and in their intimate nature, to those which are spontaneously formed by the progress of vegetation; which proves that the chemical art acts like the living powers which direct the growth and the function of plants.

14. The various acids which vegetable substances yield when treated by the nitric acid, proceed not only from the diversity of these substances, but also from the manner in which they are treated by this acid: so that, after an attentive observation of what happens in these different treatments, we may obtain at will, as far as a certain point, such or such a species of vegetable acid, or determinate proportions of two or three of these acids: for this purpose it is sufficient to stop at different periods, or to urge more or less the action of the nitric acid. We may also assure ourselves of the point at which we have arrived in the vegetable decomposition by the quantity and the nature of the nitrous gas, and the carbonic acid obtained; the more the gases are abundant, the more we are advanced in this decomposition. By a series of these beautiful results we may see, that as the consequences of the alterations is the perpetually

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increasing

increasing separation of a proportion of carbon, we can never make the vegetable decomposition proceed otherwise than in a given progression: we can never make a step backwards. An acid first formed, when it passes into another acid, does not appear any more in the first state; and we shall see that this progressive acidification, the most common and most striking product of the energy of the nitric acid, when it has once arrived at the oxalic or acetous acids, the least carbonated and the most oxygenated, if we wish to carry the nitric decomposition still further, the vegetable nature vanishes as it were under the efforts of the chemists, and the whole is reduced in his hands into water and carbonic acid. At this term, this action of the nitric acid becomes confounded with the effect of combustion.

15. It also follows from the exact, though general notions which I have just given, that by observing with much attention, and by determining with great exactness the quantities of nitrous gas, and of carbonic acid gas, formed and disengaged during the different degrees of the action of the nitric acid, those of the different acids obtained at different periods of this action, and finally those of the water and of the carbonic acid obtained at the last term of this total disgregation of the vegetable principles, we may analyze with the greatest precision both the different vegetable substances, which

which we may have taken for the subject of our operation, and the particular and successive acids which we may have obtained in the series of the different periods of this work. Thus in the course of a set of experiments which Citizen Vauquelin and myself jointly made upon the vegetable substances, we employed with great success the nitric acid, in order to determine the proportions of the primitive principles, hydrogen, carbon, and oxygen, of a considerable number of substances, the relations of whose nature and composition it was necessary for us to ascertain and compare.

16. Lastly, there are some vegetable substances upon which the action of the nitric acid is not confined to producing the effects of acidification: by converting them into acids, it sometimes changes a portion into a kind of fat oil: in others it at the same time produces a sort of resin; with the former it affords powders insoluble in water, and soluble in the alkalis, without however being fusible after the manner of the fats; with the latter it disengages and composes prussic acid, and almost always produces at the same time ammonia. Most of the last-mentioned conversions or modifications, which are effected but seldom, and which take place only with the gluten, the wood, the fibrous barks, the funguses, &c. when treated with the nitric acid, indicate in these substances a composition very analogous to that of the
animal

animal substances, to which in fact they approach by other characters and other chemical properties. We shall treat of these more in detail in the next order of facts.

ARTICLE VII.

Of the Chemical Properties of Vegetable Substances treated by the Salts.

1. AUTHORS have hitherto omitted, or nearly omitted to treat, amongst the chemical properties which distinguish vegetable substances, of the mode of their alteration by the saline compounds; because too little attention has been paid to this mode itself, and it has been thought too slight or too indistinct to be capable of serving as a character. It is true that chemists have either not yet observed the action of the salts with sufficient attention, or not found them sufficiently powerful, in order to apply it to vegetable analysis; and nevertheless, all the facts which the practice of the arts presents relative to the use of the different salts in the preservation or in the preparation of a great number of vegetable substances, exhibit a succession of phenomena which are sufficiently characteristic of these substances in order that we should not neglect the examination of them, nor reject their application to this part of

of chemistry as useless. It is this economical object which I propose here to trace, with a view to determine the properties which vegetable substances exhibit when treated according to different processes by various saline substances: to this I shall subjoin some results of chemical experiments that have hitherto been too much neglected.

2. Though the sulphates are rarely altered by most of the vegetable substances in their habitual state, though they experience no alteration from these substances in their simple contact, the case is not the same when we let them remain for a long time in this contact, or when we raise their temperature very much at the moment when it takes place. Though the saturated solutions of alkaline or earthy sulphates in general defend most vegetable substances from spontaneous alteration, this preservation is not prolonged beyond a certain term; after which the substances, being decomposed in the midst of the liquid, effect, with the aid of their hydrogen and their carbon, the decomposition of the sulphates, and gradually insulate the sulphur. It is in this manner that water charged with sulphate of lime lets fall sulphur, and exhales the fetid smell of an hidro-sulphuret when it is left for a long time in contact with vegetable substances: it is in this manner that the filth of towns, accumulated and buried with fragments of plaster of Paris, and moistened for a longer or shorter space of time, have

have filled the fragments of these materials with crystallized sulphur, which has gradually separated from the sulphate. The same action takes place by time, as is rapidly effected when we violently heat sulphates with the same vegetable substances, which convert them into sulphurets by the action of their hydrogen and of their carbon. It is known, that natural waters which contain sulphate of lime in solution do not possess the property of boiling esculent vegetables well, and I have already shown that this depends upon their saturation with this salt; lastly, it is easy to conceive that the same waters, when circumstances favour the separation, the deposition and the crystallization of the earthy salt which they contain, and when they bathe on all sides the parts of vegetables, such as leaves, stalks, barks, must form upon these substances a covering or deposition, a real incrustation of sulphate of lime, which preserves them under this unalterable and little soluble covering. It is in this manner that in the graduating sheds of salt works, the fragments of the brush-wood become encrusted with lamellated and crystalline sulphate of lime which the evaporation of the water by the agitated and compressed air separates from it incessantly.

3. Water charged with the triple and acid sulphate of alumine, alum, is also used in order to preserve various vegetable substances; but it gradually effects their decomposition, and

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mucous flakes or filaments are separated from it, which announce its alteration. The utility of this salt in the art of dyeing is known, the advantage which is derived from it for brightening, and especially for fixing and giving solidity to many vegetable colouring matters. In the history of these colours, I shall show that the property by which this salt fixes them, depends upon the strong attraction which the alumine exerts upon these matters.

4. The nitrates exert only a feeble action upon most of the vegetable substances, of which they render the texture more dense, and defend it against its own mutability, and of which they frequently also heighten the tints in their coloured parts: but chemists sometimes employ the nitrate of pot-ash with another view in the examination of these substances; it serves, by exposing the mixture with these substances to a high temperature to burn them, to destroy their hydrogen and carbon more or less completely, to extract from them the fixed saline and earthy substances, and to prove in them the existence of some metallic oxides, more especially those of manganese and iron. If we perform this experiment with care and in close vessels, so as exactly to collect the elastic fluids which are formed and disengaged, we may thus determine the proportion of the hydrogen, carbon and oxygen contained in the vegetable substance which is examined, and at the same time that of the fixed substances which remain.

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Sometimes the nitrate of pot-ash, heated strongly with the vegetable substances, yields as the residue a real prussiate, is even employed and compared in this action with that of the fixed alkalis, in order to ascertain in these bodies the property of affording prussic acid, or the colouring matter of Prussian blue compared with that which different animal substances present.

5. It is known how great use is made in domestic economy and in the arts, of the muriate of soda in order to preserve a great number of products of vegetables or vegetable parts. Thus it is customary to soak in brine, or the saturated solution of this salt, pulse, some products especially of the leguminous kind, grains or pods, roots, leaves, and even delicate flowers; the leaves of roses arranged and covered with layers of this salt, are frequently preserved in this manner in the shops of the perfumers, in order afterwards to distil them at a season more or less distant from that in which they have been gathered. Some chemists have imagined that the muriate of soda, kept for a long time in contact with liquid vegetable substances was decomposed, and that the soda was insulated; but no experiment has yet proved the truth of this assertion. This salt is frequently employed in the decoctions and distillations of vegetables in order to permit the water to assume a more elevated temperature, and thus to favour the disengagement as well as the volatilization of
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some products, the quantity of which is augmented by this process.

6. It has not yet been proposed to use the super-oxygenated muriate of pot-ash in the vegetable analysis; it is, however, one of those compounds which might prove of the greatest utility. Citizen Vauquelin and myself, in our investigations relative to detonations by percussion, have found that the vegetable substances, and especially gum, sugar, farina, like the oils, alcohol, ether, have the property of burning with great energy and fulminating by percussion, after having been mixed with super-oxygenated muriate of pot-ash. It is evident, that by performing this operation in proper apparatuses, it would be possible to collect the water and the carbonic acid formed by the union of the hydrogen and of the carbon of these substances, either with their own oxygen, or by that which should be furnished by the super-oxygenated muriate of pot-ash; and that as this salt brings only pure oxygen into this powerfully decomposing action, and leaves as residuum only muriate of pot-ash, it would be easy to determine, with the aid of its action and of its products, the exact proportions of the principles which originally compose vegetables, comprehending in them even that of the fixed substances which would remain with the residual muriate of pot-ash, which it would be easy to separate.

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7. The phosphates can be of no other use, in the investigation of the chemical properties and of the analysis of vegetables, than that of ascertaining the presence of some earths or of some metallic oxides in their fixed residues, in their coals or in their ashes; and that the fusing and vitrifying action which they exert does not differ from that which is exercised by the saline or metallic substances which have already been examined. The fluates and the borates are not capable of throwing any more light upon the subject; accordingly, nothing has been said concerning the action of all the salts upon the vegetable substances, and it has been absolutely impossible to draw any induction from them towards the knowledge of the chemical properties which characterize these organized substances.

8. The carbonates exert a little more action than the three last mentioned kinds of salts upon the vegetable compounds; carbonate of soda is frequently employed in pharmaceutical processes in order to extract more quickly, more abundantly, or more completely, some of the immediate materials of vegetables, by means of infusion or decoction in water. Thus it has long been known that when water is sharpened with a little *fixed salt of tartar*, or *unsaturated carbonate of pot-ash*, more resin is extracted from the dry woods, roots or barks; but we shall see in the subsequent order of facts that this more abundant extraction is accom-
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nied by a peculiar combination between the alkali and the root. It is generally known that the solution of carbonate of lime in a natural water, which it renders raw or hard, is an impediment to the boiling of vegetables, on account of the saturation of this water, which prevents its re-action upon the vegetable substance. It is also known that plants or their parts, immersed with water highly charged with this earthy salt, by means of an excess of carbonic acid, become covered with deposited and concreted molecules of this salt, in proportion as it quits the water, the solvent acid of which escapes into the air. By this simple process are formed the calcareous incrustations, the osteocollæ, &c. when the vegetable substance is gradually destroyed, and when it leaves a sort of hollow mould, which represents all its parts with great exactness. The carbonate of lime, deposited in minute particles in this hollow substance, assumes the form of the vegetable; and hence arise the pretended petrifications, which were formerly described with a kind of complacency, and upon which, for a long time, many dissertations were written and many absurd systems proposed; and of which the production is so simple and so easy to be explained since the discoveries of the pneumatic doctrine.

ARTICLE VIII.

Of the Chemical Properties of Vegetable Substances treated by the Metals, the Oxides and the Metallic Solutions.

1. THE metallic substances, their oxides and their solutions do, not present, any more than the salts, to the history of chemistry, real instruments that have yet been employed in the examination of the chemical properties of vegetables, though when we are well acquainted with their nature and their energy, it is easy to foresee that they may be employed for this purpose with great advantage. If we except some particular means of analysis that have been put in practice only by Bergman and Scheele, and since their time by some chemists who have followed their footsteps, for examining the new acids which they have discovered, the action of these powerful re-agents has not been considered under any general point of view, in order to investigate and appreciate, in their collective whole, the chemical properties of the vegetable substances. I shall here endeavour to give an idea of the advantage which may be derived from it, by inferring from the small number of facts that are known concerning this action, what it may be expected hereafter to furnish to this new branch of chemistry.

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2. The metallic substances collectively present only three modes of influence, which they experience from the chemical properties of vegetable substances. Either they are completely unalterable by these substances, though some weak alchemists have attributed to several vegetables the mysterious power of changing the properties of the metals, and even of effecting their transmutation. Or, they are more or less oxidable by those which, bearing the character of acid, are capable of acting as such by a more or less powerful attraction for the metallic oxides, and by the property of effecting their formation by the decomposition of the water. Thus iron and copper are suddenly coloured and gradually oxidated, corroded and dissolved by the four, ascerb, and more or less strong tasted vegetable substances as by the pure vegetable acids themselves. Finally, the metals are coloured, spotted, covered and even changed into metallic sulphurates by their longer or shorter contact with vegetable substances containing sulphur, such as the cruciferous plants, &c. It is evident that the two latter modifications of the chemical properties of vegetables with respect to mineral substances cannot afford any very great light, but only a few ideas, or general data relative to the vegetable composition.

3. The metallic oxides are more useful, and present a much stronger action than the metals

when we consider them under the same relation. The quantity of oxygen which is united with them here performs functions more or less similar to those of the acids which have been examined in one of the preceding articles. Those acids in particular which adhere the least to this combustible principle, and suffer it the most easily to be separated from their composition, are the most capable of altering the vegetable substances upon which they are made to act. It is thus that in general they tend to disorganize, to destroy, to burn the vegetable compounds; and such is the last term of their action upon those compounds. But they do not always carry their energy to this extreme point; frequently they yield only a portion of their principle, which penetrates the vegetable substances, thickens and condenses, or simply oxidates, without decomposing and completely destroying them. Such is the habitude of the vegetable oils when heated with the metallic oxides, and which, in the preparation of plasters, assume consistence at the same time that they acquire a kind of saponaceous nature. It is by the same property that so many vegetable liquors become more or less dense, flaky and tenacious, when metallic oxides are added to them, and particularly when they are heated with these substances.

4. A particular action takes place between the metallic oxides and the colouring parts of vegetables: though it may be referred in general
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to what has already been explained, it must however be remarked, that it is still stronger on account of the attraction which subsists between these two kinds of bodies. The oxygen seems in fact to be the cause of the connection which unites these two substances so closely with each other, for the metals of these oxides do not present the same property of combining with the colouring matters; but the combination thus formed does not admit of the separation of this principle; it remains united at the same time both to the oxide and to the colouring matter, the colour of which it exalts, fixes, and renders more permanent.

5. The solutions of the metals in acids produce a great variety of effects with vegetable matters, and their action differs according to the nature of these compounds. We shall see, in the history of the vegetable acids, how many different characters they present with the most of these solutions, and what effects simple and complicated attractions take place when these different substances are mixed with each other. It is necessary, in order to comprehend the reciprocal actions of the metallic solutions, and of the vegetable compounds, first to separate in the mind those effects which can be produced by the saline bodies analogous to those described in the fifth section of this work, which are frequently found to constitute part of these compounds; otherwise we might attribute to the vegetable matter what belongs

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only to substances foreign to its nature, which may in this manner be mixed with it. Thus the precipitations produced by the sulphates and the muriates, which the vegetable liquids so often present when we mix them with the nitric solutions of most of the white metals, must first be separated from the chemical effects which the vegetable substance is capable of producing. Those effects are known by the form, the colour, and especially by the examination of the precipitates.

6. When we admit this first and essential distinction, and in some measure subtract from the chemical phenomena produced by the vegetable substances mixed with the metallic solutions, those which belong to the salts already known, we find that the substances of this order are either preserved, or condensed, or coloured, or burned, or decomposed and precipitated by the metallic salts. Nothing is so frequent as the more or less intense coloration of white vegetable substances by the contact of metallic solutions; and besides the spots of all kinds with which the linen cloths employed in chemical laboratories become covered by the contact of these solutions, this kind of alteration is proved by the grand and beautiful results of the art of dyeing. The precipitation occasioned by the same compounds, added to the vegetable liquids, takes place especially with the saps, expressed juices, infusions, and decoctions. As the metallic salts are themselves
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decomposed by these mixtures, Citizen Berthollet has proposed to employ the decoction of Peruvian bark, in order to destroy, even in the stomachs of persons who have taken them inconsiderately or by mistake, the effects of the solutions of tartrite of antimony and pot-ash, and of the super-oxygenated muriate of mercury.

Fourth Order of Facts relative to the Vegetable Compounds.

Of the different Vegetable Matters in particular, or of the immediate Materials of Vegetables.

ARTICLE I.

Concerning what is to be understood by the expression or term of immediate Materials of Vegetables, and of their seat in the vegetable organization.

1. I HAVE hitherto spoken only of vegetable compounds in the aggregate, and have considered them only as if they formed one and the same substance, the nature and the general properties of which I have explained; but no one is ignorant that the matters extracted from vegetables are really very different from each other in their form, their consistence, their taste, their smell; no one confounds sugar
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with gum, or these two substances with oil, or oil with wood strictly so called. The uses to which each of these principal vegetable matters is applied for the purposes of life, teach every one to distinguish them from each other, and show that it is not only in the different structure of their parts, for example of their roots compared with their stalks, their leaves, their flowers, &c. that vegetables differ from each other, but even in the particular and different bodies, which each of their parts contain several at the same time. Thus the sweet almonds present upon their skin a reddish powder which is removed from them by friction, in their interior part an oil which is extracted by pressure, and a pulverulent mass, friable and white like starch, which remains after the expression of the oil.

2. This is the simple notion of what I term immediate materials of vegetables; they are all substances varying in their properties, in their taste, their smell, their solid or liquid state, their consistence, their nutritive, medicinal, or poisonous properties; which may be separated from the different parts of plants, and especially from the same part, and which by their arrangement and disposition in this part do immediately constitute it. Their general or distinctive character is their separate existence in the different parts of the plants, and especially the possibility of their being separated or extracted without experiencing alteration or change: so that
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they are obtained absolutely such as they were in the vegetable compounds, and without their having been caused to undergo any alteration capable of rendering their nature different from what it was in the organs of the plants of which they really formed integrant parts.

3. It is on this account that, when considered with respect to the vegetables to which they belong, and which are more compounded than they, because these materials only constitute their different parts, they were first termed the immediate principles of plants, either because they were found to possess the property and the character of really forming the vegetables by their union, or because they were separated from them by an immediate analysis, or by immediate means. This is the reason why I have elsewhere designated, by the name of *immediate analysis*, that in which we obtain by a first operation, and without complicated apparatus or processes, the matters contained in a compound; and I have chosen the principal and most striking example of this manner of analyzing vegetables. It is sufficiently evident that these materials could not be termed *principles*, except so far as they were compared with the entire plants of which they are composed; but this is an expression which ought not to be retained, because they are not really principles: accordingly chemists formerly employed them to furnish an example of what they called principles

ciples principiated, or formed themselves of other principles much more simple than they. I have therefore thought I ought to relinquish this ancient expression of *principles* of vegetables, and substitute instead of it, that of *immediate materials*, which very well expresses the notion which ought to be formed of them relatively to the vegetable composition.

4. It is scarcely necessary here to repeat, that all the immediate materials are the products of the work of vegetation; it is only of importance to observe, that a vegetable substance, or a vegetable part, never consists of a single matter only, but of several at a time, which may be separated and obtained, disjoined from each other. It follows that each of the immediate materials of vegetables must be placed in a particular kind of organs, and that its special and in some measure individual composition, is owing to the particular structure of each organ. However, it is not to be supposed that there are as many orders of vessels or of cells, as there are of immediate materials of vegetables: for the number of these amounts at least to twenty, as I shall soon show; whilst the number of orders of vessels does not exceed five that are different from each other, as I have shown in a preceding article. It follows therefore, that each class of textures, or of the organs of vegetables, contains a certain number of immediate materials different from each other. What I am about to say concerning
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the method of obtaining these materials will confirm this assertion, as we may actually extract from a single texture sometimes three or four of these different materials.

ARTICLE II.

Of the Manner of extracting the immediate Materials of Vegetables.

1. THE character of the immediate materials of vegetables being to present all the properties which they had in the plants themselves, of which they formed part, it is evident, that in order to obtain them such, we must employ means which cannot in any manner alter them. If each of these materials were particularly placed in a very distinct situation, it would be sufficient to know this situation for each of them, and to extract the substance which we wished to obtain by detaching this part; and in this case the process would be entirely mechanical. This method is practicable only for such of the materials as are contained, in the liquid form, in particular cells, or with such as in the solid or pulverulent form are separated and covered with a crust or membranous covering, or lastly, with some which, being insulated and produced by a particular excretion, are found pure on the outside of the

the vegetables, or of some of their organs, whether upon the bark, or upon the leaves, or between the open parts of the flowers, or upon the surface of the fruits.

2. It results from this distinction, that there are first of all three mechanical methods, all equally simple and equally certain, of extracting or obtaining some of the immediate materials of vegetables. When these materials, frequently susceptible of becoming thick in the air, issue spontaneously in the liquid form from certain points of the surface of plants, whether through the extremities of dilated vessels, or through the fissures and crevices which are formed in consequence of a kind of plethora or turgescence, which has violently distended the sides of these vessels, we simply gather them by hand. It is in this manner that the gums, the resins, and the balsams, are collected: nature herself preparing these juices in a peculiar class of vessels, causes them to issue out by a real secretion and excretion similar to what takes place in animals. I have indicated this general process elsewhere, under the name of the natural mechanical analysis. We see that it affords immediate materials.

3. Some immediate materials of vegetables, though very abundant in the interior of these organized and living bodies, issue from them with difficulty and in small quantity, or even in some circumstances not at all. Human industry has discovered how to remedy this inconvenience,

venience, and to adopt a simple method of augmenting their tardy emission at pleasure, or determining it when it does not take place spontaneously. Thus the resinous trees are bored with tools, in order to obtain the juices which then flow abundantly; the heads of poppies are cut to extract from them the white juice, which, as it dries upon the exterior sides of these capsules, forms opium; and the leaves of the aloe, the stalks of the euphorbium, the roots of the scammony, the trunks of many trees, in order to obtain the extractive or gum-resinous juices which are contained in them more or less abundantly. It is also by this process that the manna is extracted from the ash, &c. the sap from the birch, the yoke-elm, the beech, the vine, the saccharine juice from the sugar-maple, the elastic gum from the hevea-caoutchouc.

4. In other cases, when the proper juices which represent some immediate materials of vegetables, are inclosed in numerous vesicles arranged in some parts that are insulated, or may easily be insulated, these vesicles are opened by means of rasps, or the more or less soft and delicate texture which covers them is taken off, and they are expressed either with the hand or with the aid of a press: in this manner the juice is separated from the solid and disorganized parenchyma belonging to the vesicles in which it was inclosed. Thus the volatile oil

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is extracted from the cellular skins of the lemon, orange, and bergamot.

5. This kind of dissection, though gross and disorganizing, is not always sufficient for obtaining several of these liquid materials. When they are deeply hidden in vessels which occupy the whole thickness, the whole continuity, and especially the deep part of a fresh vegetable, or in cellules formed in the very centre of the fruits; when these juices cannot be extracted except after the whole texture has been entirely bruised or completely destroyed; when they are intimately mixed with pulpy or pasty substances which are impregnated with them: we are then obliged to bruise, to grind, or to pulverize these vegetables or parts of vegetables, and to subject the pulp or the paste which is thus formed to the more or less violent force of a press. In this manner the oily and feculent seeds are treated, in order to extract the oil from them, and the tender and succulent plants, in order to separate their juices. Bruising or violent pressure generally causes several of the liquid immediate materials to run out at the same time, with part of the fibrous, mucous, feculent, or ligneous parenchyma, which formed the solid portion; but repose and decantation are generally sufficient for purifying these materials, and separating them with sufficient exactness, without any other means.

6. Filtration through linen or paper is one
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of the most simple and most certain means of separating several of the immediate materials of vegetables when confounded together in a liquid: the light fecula, which renders the juices turbid, the mucous juices mixed with resinous or oily bodies that do not pass through fine paper already moistened, are very easily separated from each other by this mechanical process. Mere repose is frequently sufficient for obtaining this separation. Thus, for example, the acid expressed juice of lemons, of oranges, of currants, of cherries, &c. when kept for some time, deposits a more or less considerable quantity of insipid gelatinous mucilage, which was at first dissolved in the acid: but almost always this separation, this kind of parting by the operation of time, is effected only by virtue of an intimate alteration, of a more or less advanced change in the very nature of the vegetable liquids, which, as I have already shown, are extremely subject to decomposition. We ought not therefore to have recourse to this means for obtaining the different immediate materials contained in these liquids, except in the cases where they separate very speedily, and before we have cause to suspect any alteration in the combination of these materials; an alteration which sometimes takes place very speedily.

7. When the immediate materials which we wish to separate are in the solid form, and susceptible of assuming that of powder by trituration or pounding, after they have been reduced
into

into a pulp or paste, either with the water of verdure of the vegetable parts which contain them, or of foreign water which may be added to them while pounding or bruising them by different means,—they are then diluted with a large quantity of fresh water, which by separating all the pulverizable molecules, from each other keeps them first for some time suspended, and afterwards deposits or precipitates them more or less pure, insulated and separated, or deprived of the portion of soluble matter foreign to the pulverulent materials that remain in the water. This kind of washing is particularly employed in order to obtain the amilaceous and the fibrous fecula.

8. All the means that we have hitherto enunciated are entirely mechanical; there are some others which, without being equally simple but appertaining to some chemical operations, do not however require instruments or actions sufficiently powerful to alter, or at least sensibly to change the nature and the composition of the immediate materials of vegetables. Such is, in several circumstances of this extraction of the immediate materials of plants, is the action of fire. Frequently these materials, being deeply hidden or intimately contained in the interior of the vegetable cells, where they are at the same time solidified and attached to their surface, cannot be extracted from them by mechanical means; simple dissection, pounding, washing, are then no longer capable of detaching them
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from the places to which they adhere, and separating them in order to obtain them alone. Frequently also, though they do not possess the solid form which I have just mentioned, but are in the liquid form, their imperceptible drops are contained in such small cells, and at the same time surrounded with such dry teguments, that it would be in vain to attempt to extract them by all the processes of trituration and of pressure that have been indicated. In this case by macerating the vegetable parts which contain them for some hours in cold water, the sides of the cells in which they are contained become softened and distended; the small drops or the lamellated flakes of the immediate materials of which I speak begin to be insulated, and detached; and by afterwards applying a gentle heat to the vegetable parts thus macerated, the caloric which penetrates the molecules of the immediate materials we wish to obtain fuses them when they are solid, detaches them more when they are liquid, and at last volatilizes them, gives them the form of vapour, and enables them to be extracted by distillation. This is what happens in the distillation performed in order to obtain the volatile or essential oils. It is evident that this chemical process is founded upon the property which these immediate materials possess, of being fused and reduced into vapour without undergoing any kind of alteration in their nature and composition. There are, however, very few of these

materials that are susceptible of being disengaged in this manner without alteration, by the mere fusing and volatilizing action of the fire.

9. But since many other of these materials, placed in the same condition as the preceding, that is to say, inclosed in small cellules, or thick and solid, so as not to be capable of being extracted by any means of tapping, are at the same time soluble without being altered by water, alcohol, the oils, and sometimes even by the acids very much diluted: for want of other practicable processes for their extraction, one or the other of these solvents is used in order to obtain them separate. Sometimes indeed two, or even more, of these immediate products of vegetation are dissolved at the same time in the same liquid employed for extracting them: different means are then used in order to obtain them separate; slow evaporation, the admixture of different liquids, and sometimes even certain appropriate re-agents answer this purpose. Here also, as in all the foregoing processes, we imitate the method of nature, which, by the aqueous solution of the sap or of the proper juices, carries the immediate materials of plants towards the surface of these organized bodies, and frequently causes their separation by evaporation to ensue by the atmospherical air and heat.

10. In a word, all the operations, whether mechanical or chemical, but not alterant, which

are practised in order to procure the different immediate materials of vegetables, and the different products to which vegetation has given rise, however varied they may be, even in the concise account which I have given of them, and still more so in the genius and the resources of the chemist who wishes to obtain them, coincide in this single point, that they separate without causing them to undergo any change which can alter their nature, the different matters which are contained in an entire vegetable; that they enable us to distinguish these matters, and afterwards to examine each in particular, in order to determine their characters, properties, relative differences and composition; so that the mutual extraction and separation of all these immediate materials is the first species of analysis that is applied to vegetables.

ARTICLE III.

Of the Enumeration and Classification of the immediate Materials of Vegetables.

1. WHEN we have succeeded in finding the means of extracting and separating from each other, the different matters which form the vegetable compounds, and have thus become acquainted with what are termed the immediate

materials of plants, the first questions which present themselves to the mind relate to the number and difference of those materials themselves. We ask ourselves by what characters we may know this difference of the materials from each other, and to what number their species, or rather their genera, amount. Under this double question is comprehended the exposition of what I term the classification and enumeration of the immediate materials. In order to understand them well, we must revert to the period when chemists, informed by the processes of the arts, and especially by the pharmaceutical manipulations, that they might extract from a vegetable, or from the different parts of a vegetable, from its root, its stalk, or its leaves, matters different from each other,—and having endeavoured to compare these matters with each other, must have found that, notwithstanding the very remarkable difference subsisting between the numerous vegetables that ornament the surface of the globe, approximations may however be established between materials which were separated, frequently even from plants the most opposite to each other in their structure and their properties.

2. It was then that forming for the first time a distinct idea of the vegetable composition, they discovered that similar materials were found in all plants, and they began to form those approximations which I have just mentioned. They saw that amongst these materials
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some were liquid, others more or less solid; some soluble, others insoluble in water; some had a glutinous consistence, others more or less fluidity; that some were inflammable, and immiscible with water; that others had not the same inflammability, nor the same immiscibility; in a word, they thus formed series of characters or properties which served to distinguish those materials from each other. Hence gradually arose the distinction and the classification of what they have so long termed immediate principles of plants. The number of these principles soon increased in proportion as the researches of chemists were multiplied, and as the necessity was felt of regularly arranging these immediate materials in a methodical order.

3. Supposing that we already know, and are able to collect, all the immediate materials, the union of which forms in particular the collective whole of the vegetable; let us imagine, in order to represent this whole, and to proceed with order to the vegetable analysis, all the plants mixed and pounded as it were, forming together only a single mass produced by vegetation considered in its totality, subjected afterwards to the different means of extraction which I have described, and separable into a series of different matters; let us imagine this separation, carried to the point which we cannot pass without destroying the composition itself, and changing the nature of those different matters. This is the notion which we have

to form of the products of the immediate analysis, or of the immediate materials of vegetables. Each of them is then no longer considered as belonging in particular to such or such a plant, but to the collective whole of vegetable composition, to the whole mass of existing plants. Each of them, of an identical general nature, represents in some sort the same matter existing in all vegetable bodies. For example, the gummy juice and the saccharine juice are the same in all vegetables; in every plant, or part of a plant, from which they have been taken, they are exactly the same: so that with only a few vegetables, provided we choose them in such a manner that they can furnish all the compounds which have hitherto been admitted amongst the immediate materials of plants, we may be considered to proceed in the vegetable analysis in its whole extent.

4. Undoubtedly we cannot yet be certain that we have arrived at the complete discovery of all the immediate materials of vegetables: that we have extracted and know them all, that there remains nothing more to be discovered amongst these materials;—such an assertion would even be repelled by the eight or ten new principles, acids and others, that have been discovered within these twenty years past, which have been added to the catalogue of those which had before been known and distinguished. Undoubtedly this catalogue, so far from being completed at the present day, is perhaps incapable of

of ever being so, nor can we confine within any limits what still remains to be done in this respect by the human intellect. However, it is necessary to establish a kind of boundary in the present state of our knowledge; it is necessary while considering the science at the point of perfection to which it has arrived, even were it only in order to draw up the catalogue of the notions that have been acquired, to present an enumeration of these materials; and it is in order to present this enumeration that the most able and most ingenious chemists have particularly occupied themselves for some years past.

5. Some have taken for the basis of the classification which they have adopted, the mode itself in which they were extracted, or the order of analysis. Thus Rouelle, in his table of the vegetable kingdom, has treated successively of the analysis of plants, or of the materials separated by a gentle or a violent fire, by water, by fermentation, and by alcohol; others have followed a method relative to the order of the dissection of the plants, or of the natural and simple extraction of their materials with respect to the structure or the different vascular systems of vegetables: this is the course which Bucquet has followed. Some others have founded their principal divisions upon the properties made use of in common life, or in the arts. Most have considered them in no other point of view than that of medicinal preparations, and have followed only a
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pharmaceutical order. A very great number have simply treated of these materials according to the series of different operations to which they are subjected. None of these methods has yet been systematic, and founded upon a comparison of the properties of the different immediate materials of vegetables.

6. When we consider in the most general manner, or under the most extensive point of view, the different modes of classifying the products, or immediate materials of plants, we find that only four principal methods of division or of classification can be admitted amongst them. And in fact we may follow first the anatomical order, and examine successively the materials of the roots, the bark, the stems, the woods, the leaves, the flowers, the fruits and the seeds, or even directing our attention to the interior structure, those of the common, the proper, the utricular, and the cellular vessels. But this first order represents incessantly the same objects which we should thus be obliged incessantly to reconsider; for each of the parts of plants, though very different in their structure and respective situations, frequently contain matters analogous to those which are contained in others, and it is evident that the mere seat or place does not indicate a difference sufficiently constant or sufficiently marked to afford a certain basis for the distinctions to be established between those different materials.

We may choose for this basis the properties themselves of the materials, distinguishing them into nutritive or alimentary, medicinal, combustible, textile, fermentescible, solid and permanent, &c. But this second method, which may have its advantages in the applications of the science, has however too few relations with the philosophical views, and the individual progress of the latter, for it to be capable of affording the advantage which is sought in it.

7. A third method of distinction between these several vegetable bodies or compounds might be founded upon the really chemical characters, or the intimate properties by which they are separated and known. For example, some immediate materials are mucous, others are saccharine, some are acid, some oily and inflammable; some are coloured, some solid and insoluble, and some approach to the animal substances. We might even combine with this first division that which considers the materials with respect to their state or consistence as liquid, soft, fibrous, glutinous, lamellated, pulverulent; those also which distinguish them by their taste into sweet and insipid, sweet and saccharine, acid, acerb, bitter, acrid; by their smell, into odorant, inodorous, fetid, aromatic. This method of disposing the materials of vegetables is one of the most useful and most philosophical; it depends upon the chemical properties on the one hand, whilst on the other it leads to the knowledge of the advantageous
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or useful properties: it therefore in every respect merits the preference beyond the two first, and it will soon be seen that it is the method to which I approach the nearest.

8. Lastly, the fourth method, the most philosophical of all, which supposes the greatest advancement in the science, and which can yet be presented only in idea or expectation,—which, in a word, is far from being able to be brought to that point of perfection which it may hereafter attain, and which will then be followed with one accord by all who shall occupy themselves with the study of nature, is that which, founding itself upon the progress of vegetation, of vegetative chemistry, shall arrange the immediate materials according to the order of their successive formation in plants, and dispose these materials according to time and the periods of their appearance and their creation. In order to comprehend this last division perfectly, I must here mention, that notwithstanding the little real progress which chemical science has yet made in the knowledge of the phenomena of the growth, and of the particular vitality of the plants, it has however already elevated itself so much in its conceptions and experiments, as to know that the immediate materials of vegetables are formed successively, at different periods of vegetation, that each of them belongs in some measure to one of these periods; for example, the mucous sap and the mucilage to the first periods of vegetation,
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the saccharine substance to the germination and the maturation of the fruits, the ligneous substance to the growth and frutescence, the oil and the wax to the fructification ; that all these different materials are only progressive modifications of the same matter, of a single primitive, ternary or quaternary compound, which seems to commence with the sappy gum, and to finish with the wood and bark ; and that by thus investigating, either from an attentive examination of the phenomena of vegetation themselves, or by a comparative analysis of the different vegetable materials, an analysis placed in some measure at the other extremity of this philosophic chain, we shall be able hereafter to find out the order, the succession, the epocha of the formation of each immediate vegetable matter.

9. It is by combining these two bases, as far as the state of the science has permitted me, the chemical characters on the one hand, and the succession or the relative period of the formation on the other, that I shall here give the classification and the enumeration of the immediate materials of vegetables, the number of which I reduce to twenty different matters, viz.

A. Sap.

B. Mucous matter.

C. Sugar.

D. Vegetable albumen.

E. Vegetable acid or acids.

F. Extractive.

G. Tanin.

H. Starch.

I. Gluten.

- I.* Gluten.
- K.* Colouring matter.
- L.* Fixed oil.
- M.* Vegetable wax.
- N.* Vegetable oil.
- O.* Camphor.
- P.* Refin.
- Q.* Gum refin.
- R.* Balsam.
- S.* Caoutchouc.
- T.* Ligneous matter.
- U.* Suber.

10. I must observe, that of the twenty materials which I have just enumerated, the six first are frequently dissolved in the water of the plant, circulating with the sap, or are susceptible of dissolving in the water which we add to them; the three following, the starch, the gluten, and the colouring matters, have a pulverulent or lamellated form; the oily substances, from the fixed oil to caoutchouc inclusively, inflammable and insoluble in water, are inclosed in particular cells or vessels; and the two last, the ligneous substance and the suber, form the solid insoluble part, the common support and integument of all the parts of vegetables. Of these twenty substances, there are at least four which have been mistaken by the chemists before me, or which they have not distinguished from the other materials, or have neglected to study as particular products; these are the albumen, the wax, the ligneous matter, and the suber. Each of these immediate materials,

terials, the properties of which I am about to examine, ought to be considered as a peculiar genus of vegetable compounds, to which the species or varieties will be referred, according to the slight differences they possess in the different vegetables: in examining each of these bodies, I shall consider successively and in the same order for all.

- A. The seat or situation which it occupies,
- B. The processes for its extraction.
- C. Its chemical properties.
- D. Its chemical products.
- E. Its species or varieties.
- F. Its uses.

ARTICLE IV.

Of the first of the immediate Materials of Vegetables, namely the Sap.

A. Seat.

1. I CONSIDER the sap as the first of the immediate materials of vegetables, because this is the liquid which in fact shows itself the first in vegetation. When the motion which takes place in trees and plants at the first warmth of spring, and after the long sleep into which they have been sunk by the cold of the winter, begins to dilate their buds, and cause their leaves
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to unfold themselves, the sap which swells the common vessels, and perhaps even at this period all the orders of vessels of these organized bodies, opens as it were, by its progress, the scene of vegetation; it ascends from the root into the stem, and from this by the medullary prolongations under the bark, and to all the extremities of the trees and plants which it dilates, which it develops, and which causes it to grow with greater or less activity. In this plethora, this general turgescence of the vessels of these bodies, some parts of their sides are unable to resist the distension which they experience; fissures, crevices are formed; the sap opens itself a vent on all sides, and flows out with more or less force, either by the cortical fissures, or in the vicinity of the buds, or at the extremity of the stalks.

B. *Extraction.*

2. If we cut young branches at this period of the motion of the sap, and place the extremity that has been cut in a bottle, there issues out a quantity of this liquid sufficient to enable us to obtain nearly half a kilogramme (from twelve to sixteen ounces) in twenty-four hours. If we pierce the trunk of the tree horizontally with an auger, there runs out a sufficiency to enable us to collect quantities useful in several of the arts, and especially in the preparation of an acidulous and vinous liquor, much employed and very useful in several of the forests of Germany.

many. In America, the sap of several kinds of maple is obtained by the same process, in order to extract from it sugar similar to that which is furnished by the species of gramen cultivated in the colonies of the Europeans in America. It was long ago known, from these two kinds of experiments upon a very large scale, that the sap of trees contains saccharine matter, and that it is susceptible of fermenting or yielding a vinous liquor; but these first notions were very remote from the remarkable discoveries that have been made some years ago upon this subject by Citizens Vauquelin and Deyeux.

C. *Physical Properties.*

3. SAP is a limpid and colourless liquid, which was long believed to be pure water, and which on that account was denominated *tears*. Its taste is sometimes insipid, slightly saline, sometimes sweet, almost always briskly acid or acidulous. Immediately after it has been extracted from the trees, it contains no foreign substance, no solid matter, no flakes, and it has no colour; it often froths much upon the slightest agitation. When we pierce, or even when we saw trees as far as their centre, and apply the ear close to the cut of the saw, we hear a crackling or a rustling noise, perfectly similar to that of bubbles of air, when, by the effect of compression, they pass through a liquid, from which they escape with difficulty. When kept for some time in a well-closed

closed bottle, a spontaneous effervescence takes place, which pushes out the cork, as is done by fermenting wine: it then becomes strongly acid, powerfully reddens the blue vegetable colours, and is turbid in a more or less sensible degree. Its consistence is never mucous or ropy; on the contrary, it is very light and liquid. It cannot therefore be confounded with any of the materials that are to be examined after it, because it has none of their apparent characters.

D. *Chemical Properties.*

4. SAP exposed to the fire becomes filled with bubbles, swells and readily yields carbonic acid gas; when it is evaporated, it diffuses a strong smell of vinegar; it affords an extract of a beautiful red colour mixed with tanin; the latter exists in the sap of the oak and the beech; it sometimes affords a small quantity of albumen, but then it contains no tanin; we find saccharine matter in it, especially in that of the maple and the birch; it becomes brown during its evaporation; it also affords carbonate of ammonia when it is distilled to dryness. Amongst its products we distinguish vinegar, which is the more abundant, the longer it has been kept after its extraction from the trees, before the period at which it is subjected to the action of the fire. In its coal we find carbonate of pot-ash, carbonate of lime, muriate and sulphate of pot-ash. These are the phenomena described by Citizens Deyeux and Vauquelin, after the treatment of the sap by the fire.

5. We

3. When we leave sap exposed to the air, it assumes the yellow and the brown colour; it deposits many flakes which Citizen Deyeux believes to be a kind of vegeto-animal or glutinous substance, held in solution by the acetous acid. It soon ferments, yields a great quantity of carbonic acid gas, becomes more intensely sour, and forms a kind of vinous and acidulous liquor, from which we may extract alcohol by distillation. If we leave it for a longer time to become altered in the air, it assumes a fetid smell, becomes very brown, deposits a filamentous and gluey mucilage blackish at its surface; at last it becomes ammoniacal. Thus it is susceptible of the three fermentations, the vinous, the acid, and the ammoniacal or putrid,

6. Sap mixes in all proportions with water, which dilutes, extends, and dissolves it, when it is thick and viscous, which also facilitates the separation of its different flakes, and the motions of spontaneous alteration, which the different materials of which it consists are capable of experiencing. It only acquires less colour after having been diluted with water.

7. The powerful acids expel from it the carbonic and the acetous acids, and form calcareous salts with a base of pot-ash, which are found by evaporating the saps to which they have been added. They also separate from them concrete flakes, at least in several kinds of saps. When they are concentrated, particularly the sulphuric acid they burn and blacken them, by
4 carbonating

carbonating the extractive and glutinous materials which they contain. The nitric acid converts their extracts into mucous and oxalic acids; the latter shows that lime exists in them.

8. The alkalis combine quickly and easily with sap; they saturate the excess of acid, which it almost always contains; they prevent its deposition and precipitation so quickly as it would do spontaneously; they retain in solution the tanin, the extracts, or the vegeto-animal substance which it sometimes appears to contain.

9. The salts, properly so called, merely dissolve the materials of sap, check its fermentation, preserve its integrity without causing it to undergo any alteration, and without being able to assist in rendering us acquainted with its principles.

10. The same is the case with the metals and metallic solutions; they cannot afford us much light with respect to the nature of sap: the first become coloured or dissolved; the second sometimes unite with the acids which are contained in it, and saturate them; metallic solutions are entirely precipitated in it, either by the extractive matters, or by the acetites which form part of this vegetable liquid, and act upon the metallic salts by double elective attraction.

11. Citizen Deyeux has concluded from his experiments that sap is a compound liquor, containing calcareous acetite and a vegeto-animal matter united with the acetous acid: it is to
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this matter he attributes the spontaneous precipitation of the saps in the air, the formation of the ammonia, and the smell of burned rope, which is diffused by the residuum of its evaporation when placed upon ignited coals. He compares this substance with the glutinous matter of cheese, equally soluble by the acetous acid, and forming ammonia.

12. After the experiments of Citizen Deyeux, made in Germinal and Floreal of the year 4, Citizen Vauquelin instituted a similar inquiry respecting the saps in the same season of the year 5. The first had examined the sap of the yoke-elm and the vine; the second has analyzed those of the elm, the birch, the beech, and the yoke-elm: in all he has constantly found acetite of pot-ash and acetite of lime, sometimes acetous acid in excess, sometimes carbonate of lime and carbonic acid, a saccharine matter, tannin, gallic acid, two very high-coloured extracts; the one soluble in alcohol, the other only soluble in water. Hence he concludes, that all the saps are acid, that they contain either acetous or carbonic acid, or both at once; that part of the acetous acid is combined in them with the pot-ash, and the other with lime: that the saps which contain acetous acid in a free state contain no carbonic acid, neither free nor united with a base, but that both acids are often combined with these two bases in the same sappy liquor; that all the saps contain vegetable matters, which become coloured in

the air, and by the effects of heat; that they all yield ammonia by distillation; that muriate and sulphate of pot-ash are also found in all.

13. It is easy to conceive, from the interesting discoveries of the two French chemists, that sap is a very much compounded liquor, in a certain degree comparable with blood, containing a large part of the materials of plants, disposed to form them all, according to the different places which it is destined to traverse, or in which it resides. I shall show hereafter, that a portion of the substances which it holds in solution, proceed from the soil itself in which the roots are situated.

E. Species and Varieties.

14. WE are yet far from having examined a sufficient number of species or varieties of saps, to be able to draw general and certain conclusions with respect to their comparative properties. Hitherto only the saps of the vine, the elm, the birch, the beech, the oak, and the yoke-elm, have been analyzed. The following is what already results respecting the difference of those liquors, according to the comparative analysis that has been made of them.

The saps of the oak and the beech contain gallic acid and tanin; they cannot at the same time contain animal substance, because this principle would precipitate it. Accordingly, by mixing these saps with white of egg, with a solution of
4 glue,

glue, and with a solution of the gluten of flour in vinegar, Citizen Vauquelin has obtained a precipitate of tanned animal matter. After having separated this precipitate, the supernatant liquor contained gallic acid, acetites of pot-ash and of lime, and two extracts: the one soluble in alcohol; the other mucilaginous, infoluble in this liquor, and capable of being converted into mucous and oxalic acids by the nitric acid.

The saps of the birch and the maple contain a sufficient quantity of saccharine matter for it to be extracted with advantage, and for their forming a kind of vinous liquid by the fermentation which they are capable of undergoing.

Finally, there are several saps which contain a remarkable quantity of nitrate of pot-ash.

It would be superfluous here to observe, how useful and interesting it would be to analyze the saps of different trees; what interesting results might be obtained from this analysis, for the completion of our chemical knowledge respecting the vegetable compounds, and afterwards for vegetable physics.

F. *Uses.*

15. IT is not difficult to see that the use of the sap in the economy of nature is to serve the purposes of vegetation by developing the parts of plants, and the formation of the different immediate materials of plants; that this liquid

is the principal source of all the vegetable liquors, and even of their solid materials.

16. Though it cannot be said that the saps are real food for man, those which contain sugar may to a certain degree answer this purpose. They are used for preparing drinks, vinous, strengthening and refreshing liquors, which are highly esteemed by physicians, and employed in many parts of Germany in the treatment of acute and febrile diseases. Besides which, the use which is made in North America of the sap of the maple, in order to extract sugar from it, which affords a substitute for that of the African or American sugar-canes, proves that we may at least rank this liquor in the class of auxiliary foods.

Addition to the Article on Sap, relative to the expressed Juice of Plants.

1. WE may rank after the sap, and even consider as a species of this liquid, that which is termed the juice of plants, and which is extracted, either for medicinal use in the laboratories of pharmacy, or as a matter useful in the arts in some manufactories. In fact, these saps, from whatever plants we may take them, or from whatever fresh vegetable we may extract them, are composed in a great measure of sap; for by pounding these organized bodies in a mortar, we break and open in all their continuities

nities the common or sap-vessels which are filled with it. The process for obtaining them is extremely simple. The fresh, green, and succulent plants are chopped small, or pounded in a mortar of marble or wood; the latter is especially preferred when the operation is to be performed upon acid herbs; they are moulded with the hand into a kind of ball, which is forcibly pressed, or they are inclosed in a piece of linen, which is tied together, and afterwards put into a press; sometimes, in order to cause the juice which they contain to flow freely, water is added, particularly when the plants are too dry, or when they are too viscous.

2. As by this manipulation we obtain juices very much coloured, very turbid, and much charged with the fibrous parenchyma of the plants, which the pestle or the cutting instruments have lacerated in all their points, it is evident that these juices are far from being the pure liquid which distended their vessels. They not only contain sap, but they are also mixed with the liquids inclosed in the proper vessels, the mucilages separated from the utricles and the cortical layers, with fecula or fibrous parts, more or less minute, torn away from the texture of the vegetable itself. Of these different matters thus added to the sap, some, being dissolved in water, cannot be separated from those which belong to the sap itself, except by chemical processes more or less complicated; others, being only disseminated

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and suspended in the liquid, and consisting of solid molecules, are much more easy to be precipitated from it.

3. The separation of the latter, which destroys the transparency and purity of the expressed juices of plants, is especially recommended in the laboratories of pharmacy, in order to effect what is called defecation: rest alone is frequently sufficient to answer this purpose. When the juice is very fluid, the fibrous particles of the fecula approach to each other, collect together, deposit themselves in the form of flakes more or less green at the bottom of the liquid, which only requires to be decanted in order to have it sufficiently pure. This simple process, it is true, can only be used in those cases where the juice is not susceptible of spontaneous change, where it contains no volatile and odorous principle which it is necessary to preserve, in order that it may enjoy all its medicinal properties: for the spontaneous precipitation, and the complete deposition of the fecula, frequently require several hours; and this time is sometimes sufficient for an interior motion or some alteration to establish itself in the juices, especially when the temperature is elevated above fifteen degrees in the atmosphere.

4. Sometimes filtration through paper without size is had recourse to, in order to separate the fecula from the juices. This process is practised only for the most fluid and lightest juices, that are required to be purified quickly; such

such as those of house-leek, purslain, lettuce, succory, &c. In other circumstances, especially when we have to treat juices a little viscid, mucilaginous, thick, and containing nothing volatile, as the juices of borage, bugloss, pellitory, or nettles, we mix them with a little white of egg and water, then stir them, cause them to boil for a moment, and filtrate them when they have cooled. The albumen, as it coagulates, forms a reticular substance, which, in its ascent, detains and separates all the feculent particles that troubled the liquid. But the heat of the ebullition gives them a much deeper colour than they had before, and alters them sensibly; so that this is not merely a defecating, but an actually decomposing process.

5. There are some juices whose alterability is so great with respect to the odorous matter which they contain, and which it is necessary to preserve for the medicinal use for which they are destined, that we have been obliged to seek means of separating the fecula with sufficient celerity not to leave them time to become altered, and gentle enough not to change or affect their intimate nature. Such is the process employed for defecating the juices of cresses, cochlearia, beccabenga, and all the antiscorbutic juices which have an acrid and pungent odour. It consists in putting them into a matras or bottle, the mouth of which is covered with a piece of wet parchment perforated with several punctures with a pin,

a pin, plunging this bottle into another vessel filled with boiling water, and suffering it to remain for some minutes in this bath; we soon see its fecula collect in concrete flakes, which gradually deposit themselves at the bottom; we then filtrate the liquid, which is found to have lost nothing of its smell or of its properties. This process is founded upon the nature of the fecula, which appears to approach to that of albumen or glutinous matter, and as such to be coagulated by the action of the fire, and afterwards cease to be capable of being suspended in the liquid.

Lastly, another means is sometimes employed, in order to defecate the juices of plants, by adding to them vegetable acids, lemon-juice, vinegar, sometimes even wine, and especially white wine: this practice is especially recommended in some foreign dispensaries. Indeed, it is only proposed for the antiscorbutic juices, with which we thus join a substance that can only augment their energy, and add to their medicinal virtues; it is also founded upon the albuminous and coagulable property of the feculent matter. It is very evident that if these juices contain glutinous matter, this principle must remain in part dissolved in the defecating acid.

7. The purified or depurated juices of plants have great analogy with sap; like it, they frequently contain a free acid, and almost always acetites, either of pot-ash, or of lime; like it, they

they are coloured by the action of the fire and the air; like it, they precipitate coloured flakes by the addition of oxygenated muriatic acid; like it, finally, they yield by evaporation, red or brown extractive matters. They, however, differ from it in the circumstance that saccharine matter is rarely found in them, and never tanin or gallic acid. In general, the two latter materials are only met with in the saps of the trees; they have the most intimate relation with the ligneous substance; they constitute either the source or the depositary of this solid substance. The juices of plants differ also from sap in the circumstance that we frequently find in them a greater or less quantity of gummy mucilage, which exists but very rarely or never in the latter; and we see that these differences depend either upon those of the young, succulent, herbaceous plants, from which the juices are expressed, or upon the manner itself that is employed for obtaining them, the violent pressure which is practised. Citizen Vauquelin has lately found the malate of lime to exist in considerable abundance in the juices of the house-leek (*sempervivum tectorum*), and of several species of *sedum*.

8. In a chemical point of view, the expressed juices belong much more nearly than the saps to the history of the extract, or extractive in general. When we evaporate the former liquids by the action of the fire, in order to obtain what are termed *inspissated juices*, such as the
juice

juice of borage, of the elaterium or wild gourd, the juice of the acacia, that of hypocistis, of floes, opium, &c. we actually prepare a kind of extracts or extractive mixtures, considerably resembling those that are obtained by the action of water upon the dry vegetable substances. I shall speak of them again under this relation in one of the subsequent articles.

ARTICLE V.

Of the second of the immediate Materials of Vegetables, of the Mucus, or the Mucilages and Gums,

A. Seat.

1. MUCUS, mucous substance, or mucilage, so easily distinguishable by its viscosity, its thick and gluey consistence, its faint or insipid taste is found in many vegetable parts different from each other: it is one of the most diffused of the immediate materials of vegetables, and which the work of vegetation seems to form the most easily and frequently. It is known in all the organs of plants, when by pounding them their particles adhere to one another as it were, in a pulp, when all the substances that are brought into contact with them, stick and adhere to them, when they join with this first property an insipidity, or faint taste more or less peculiar, and an inodorous quality.

2. It

2. It is found in a great many roots, such as those of the mallows, consolida, the lily, &c. and in general in those of young plants, in such as do not naturally become ligneous, or those which only become so very late. It exists in the stalks, and especially under the epidermis, and between the last cortical layers, which it moistens, through which it frequently forms itself a vent, in order to run out, as we so often see in the fruit-trees, especially in those that produce stone-fruits. It is also found in the leaves of a great number of vegetables, almost at all periods of vegetation, and in all towards the commencement of their opening and unfolding themselves. This we may ascertain at this period, by crushing between the fingers the delicate texture of the leaves, which strongly adheres to the skin; it frequently accompanies the pulpy or parenchymatous texture of the fruits, always the integuments of the seeds, sometimes the exterior, sometimes the interior. Before the cotyledons are formed, and have become dry and farinaceous, they exist under the gelatinous, transparent, and viscous form of a mucilaginous substance.

3. Very frequently the mucus is intimately mixed, or even combined with some other immediate principles of vegetables, especially with sugar and the acids, as we find to be the case in most of the fruits from which the juice is easily extracted; sometimes with the amilaceous fecula or starch, with the fixed oils,
with

with the resins, or the gum-resins. When it is alone and insulated, it frequently forms a real plethora in the different organs of the vegetables, and particularly between the external laminæ of the cortical layers below the epidermis, especially towards the extremities of the branches, of the petioles, of the peduncles of the flowers and fruit; it is most frequently at those points where there are a great number of interruptions and fissures in the continuity of the epidermis, that the mucus issues and runs out on the surface of trees, which frequently contain a large quantity of it.

B. *Extraction.*

4. When the super-abundance of the mucous juice violently distends the vessels of trees (for the same phenomenon is not observed in the herbaceous plants) those vessels become ruptured, and the mucilage, more or less thick, viscous, and gluey, issues in drops which speedily dry in the air. Then the surface of these trees, and especially the points of the insertion of the branches, the twigs, the petioles, the leaves, the peduncles, the fruits, and the fissures which are sometimes formed upon them, become covered with these drops of mucus, which gradually accumulating and drying in the air, give rise to tears, transparent round irregular bodies, sometimes to stalactiform elongations, to a kind of blades or
3 ribbands,

ribbands, smooth or striated, white, yellowish, reddish or brown, which are known and collected by the name of *gums*. Thus the traveller, who journeys through the interior of Africa, finds every where in his course the tears of the gum Arabic, which hang from the twigs of the acacia, or *mimosa nilotica*, which grows in abundance in those countries. Thus in our orchards and gardens, the apricot, the peach, the plumb, the cherry, the almond-trees become covered at the beginning of the summer with gummy tears, which are separated from them, and are known in commerce by the name of gum of the country (*gummi nostras*).

5. When the gummiferous trees, especially the old, are surcharged with this mucous substance which swells their vessels, longitudinal orifices, in the direction of the axis of the trees, are sometimes made in their bark with success, for their preservation and health. In this case, the gummy juice issues out more or less abundantly by these incisions, and may be collected in large quantities. As nature furnishes it in sufficient abundance for all the uses to which this substance is appropriated, this operation is not performed for the purpose of obtaining it, but merely for the relief of the trees.

6. When the mucus, in the form of a thick and viscous liquid, is intimately or profoundly inclosed in the organs of vegetables, as in the roots, &c. when it is applied in dry and polished layers to the surface of the shining or glossy feeds,

feeds, such as those of flax; when it exists in thin, but not dry layers, under this integument of the feeds, as in all those of the cucurbitaceous plants, the pippin-fruits, the quince, &c. we can neither extract it by trituration nor by pressure. In this case we dilute or even dissolve it with the aid of hot or boiling water; and in this state it is more especially called *mucilage*. Thus the juices of some young mucous and gluey leaves, when they have been crushed and reduced into a pulp, especially such as those of borage, of bugloss, of scabiosa, &c. cannot easily run out, without water being added previous to their expression, on account of the large quantity of mucilage which accompanies their sap, and which we are obliged to extract together with it.

7. The mucilage frequently being combined with a vegetable acid, and dissolved or rendered fluid by this acid, runs out together with it, and affords a four juice, possessing a greater or less degree of viscosity. Such are the juices of the lemon, the orange, the currant, the strawberry, the raspberry, the cherry, the plumb, the peach, the apple, the barberry, the service, the grape, &c. &c. we unite their two constituent materials, still more intimately together, prevent their separation, and impede their alteration, by dissolving in them a sufficient quantity of sugar, as is done in the preparations known by the name of *con-serves*. But if, instead of following this practice, we leave these juices to themselves after
having

having extracted them from the fruits, at the end of some hours, and especially with the contact of the air, they deposit the mucilage which they contain in a gelatinous form; we may separate them by placing these liquids which have become thick by deposition, upon a close and fine sieve, which suffers the more liquid acid part gradually to run out, and detains the mucous juice. This is washed with a little pure water, in order to separate the portion of acid which it still contains. Frequently it retains a small quantity of colouring matter, which gives it a yellowish, fawn, or rose-coloured tinge. By drying, it assumes more colour, diminishes in its volume, preserves its transparency, and becomes dry and brittle like a real gum.

8. There are some cases in which the mucus accompanies the oils; those that are termed fixed are particularly impregnated with it: it then forms what Scheele terms the *mild principle* of the oils. It is not separated from them without much difficulty; sometimes it is spontaneously precipitated from them by rest, and presents itself at the bottom of these liquids as a flaky deposition. It always impedes their combustibility, and contributes to form the knobs on the wicks of lamps; a more or less abundant portion of it is deposited when we heat these oils, and a sort of precipitate is formed, which impairs their transparency, and renders them viscid. It is also separated from these inflammable bodies by the action of several re-agents, and especially

especially by that of the metallic oxides, as Scheele has observed, and as I shall show in the history of the fixed oils.

C. Physical Properties.

9. The mucus exists in three principal states, either in or out of the vegetables. It is solid or concrete and friable, and in fragments or pieces more or less large; it is almost always spheroidal on the outside of the trees; it is either sprinkled in the form of powder, or spread in thin layers upon the surface of a great number of seeds: lastly, it is in the state of a viscid, gluey, thick liquid in the roots, the stalks, the internal part of the seeds. Its liquid state varies greatly in density, according to a multitude of circumstances, which tend to thicken or to dissolve it, especially according to the dryness or moisture of the weather, according to the proportion of water which the plants are capable of absorbing.

10. The viscid nature of the soft mucous substance, the kind of glutinous or agglutinating consistence which it possesses without being elastic, the tendency to adhere which subsists between its own particles, and communicates itself to the different surfaces between which it is placed, joined with the brittle and pulverizable property which it possesses when sufficiently dry and gummy, prove that it owes the first of those characters to the adhesion
which

which its particles contract with water, and their attraction for this liquid.

11. Mucus when very pure is colourless. It is clear and transparent like water. It never becomes coloured, except in consequence of its having undergone a first degree of alteration in its intimate composition, or being mixed with some foreign substance of a colouring nature. It has no taste properly so called, it is only sweetish and insipid. Every taste besides this, whether astringent or saccharine, or bitter, proceeds from some foreign substance associated with it. It is also perfectly inodorous: when, reduced into powder or into vapour by the means of boiling water, it is introduced into the nostrils, it excites only a very slight impression, which would scarcely be sufficient to apprise us of its presence without the aid of the other senses, of the sight or the touch. Its specific gravity, from the purest to the most mixed gum, is to that of water, as 13,161, or 14,817 to 10,000.

D. *Chemical Properties.*

12. Mucus, exposed dry or in the state of gum, to an open fire, or with the contact of the air, is fused, swells, becomes yellow, red, and brown; is reduced to coal, augmenting greatly in its volume, and exhales successively, during this alteration, an aqueous vapour, a more dense smoke of a pungent sour smell, which is not unpleasant; it produces only some light
VOL. VII. O flames:

flames: at the termination of this action it leaves a light and very voluminous coal. When distilled in an apparatus properly disposed and provided with pneumato-chemical tubes, it affords water, a reddish acid liquor, some drops of brown oil, carbonic acid gas, a little carbonated hydrogen gas, and a coal much more bulky and of a different form from the gum, of a single piece when this has been introduced in powder or in small fragments into the crucible. The water disengaged has been composed in a direct way by the combination of the hydrogen and the oxygen of the gum, and was not contained in this body. The oil, which is in very small quantity, is the product of a portion of carbon and hydrogen, united and sublimed together; the carbonic acid gas proceeds from a portion of the carbon burned separately by the oxygen at a high temperature, and perhaps even from a part of the water already formed, decomposed by the carbon, set free, and brought to a red heat: which seems to be proved by the carbonated hydrogen gas which accompanies it, and which, like the first gas, is not developed, but at last, and when the action of the fire is the strongest. The coal, which forms about a fifth part of the gum, and which remains in the retort, is light, porous, easy to be burned; it yields but very little ashes, in which are found some traces of pot-ash, a small quantity of carbonate, and of phosphate of lime.

13. With respect to the acid, one of the new
and

and most remarkable products of the decomposition of mucus, it is a compound formed at the expence of a portion of the carbon, the hydrogen, and the oxygen of the gum; a compound which was not contained in this natural insipid product, that does not redden the blue colours. This acid is a creation of the fire. As it will several times present itself in the examination of the immediate materials of vegetables, and as it is not otherwise found amongst the natural products of plants, it is necessary here to explain what is known of its properties or characters. The first chemists who have mentioned it knew it only by the name of spirit, or acid phlegm of gum; and Citizen Guyton termed it sirupous acid, because it is also a product of the distillation of syrup, and as he had obtained it in considerable abundance from distilled sugar. Lastly, in order to generalize its nature, its formation, and its origin, it has been termed pyromucous acid. He has not yet studied all its combinations: however, what has already been collected respecting its properties is sufficient to distinguish and characterize it. Chemists have erroneously believed it to exist ready formed in the gums; they have admitted it in a saponaceous combination with oil, and nevertheless there exists as little oil as acid ready formed in these vegetable compounds.

14. The pyromucous acid is always liquid; it is neither more nor less volatile than water;

it does not abandon it when it is distilled; we can neither obtain it in the gaseous nor in the solid form. It has a pungent, sour, and empyreumatic taste; it has a smell analogous to that of radishes, or of roasted bitter almonds: in this respect it in some measure resembles the prussic acid. At a high temperature it is decomposed into carbonic acid and water; it always leaves a coaly stain when it is distilled in a retort. When we expose it to the frost, it becomes concentrated on account of the portion of water which separates from it. It produces upon the skin an orange-coloured or reddish stain, which disappears only with the cuticle. With lime it forms a calcareous pyromucite of considerable solubility. Its saline combinations are not known; we only know that they differ from all the others. It disengages the carbonic acid from all its bases, and produces a lively effervescence with all the carbonates. It attacks neither platina, nor gold, nor silver, nor mercury; it corrodes and oxidizes copper, iron, lead, and tin; it crystallizes with the oxide of lead and the oxide of iron. The order of its elective attractions, according to Citizen Guyton, is the following: pot-ash, soda, barites, lime, magnesia, ammonia, alumine, the metallic oxides, water and alcohol. We see from this short exposition, that the properties of this pyromucous acid are as yet scarcely known, and that what has been determined concerning them is

merely

merely sufficient to show that it differs from all those that have hitherto been discovered; no use is made of it.

15. The gums are absolutely inalterable by the air; the mucilage only thickens and becomes gummy. Water easily dissolves the mucus, which gives it a great degree of viscosity, as every one knows. Heat greatly aids the action of the water, and enables it to dissolve more quickly a larger quantity of gum; when too strong or too long continued it evaporates it, and at last reduces the mucilage to the dry and gummy state. Mucus dissolved in water is not altered; of all the immediate materials it is that which most resists spontaneous alteration.

16. The weak or diluted acids only dissolve mucus without alteration. The concentrated sulphuric acid, by its spontaneous action upon this body, decomposes it, converts it into water without itself experiencing any change. It thus sets its carbon free, and changes part of it into acetic acid. The same is the case with the muriatic acid, which reduces it to coal in the course of time. The oxygenated muriatic acid acidifies it; but it is the nitric acid that acts the most powerfully upon it.

17. The nitric acid, slightly heated in the proportion of two parts upon one of mucus, till a small quantity of nitrous gas and of carbonic acid is disengaged, afterwards throws down by the cooling of the whole liquid and dissolved mass, a white, slightly acid powder, which Scheele has called acid of sugar of milk, the lactic

fachlactic acid of the methodical nomenclature, as it has been especially obtained with the sugar of milk. As it is not peculiar to the latter substance, and as it is prepared with all the mucilages, I term it mucous acid.

It is in the form of a white powder, a little granulated, of a slightly sour taste; it is decomposed by the action of fire, yields an acid phlegm which crystallizes in needles by rest, a small quantity of oil of a blood-red colour, acrid and caustic, carbonic acid gas, and carbonated hydrogen gas: it leaves a great deal of coal; a part appears to sublime in brown needles or plates of a smell analogous to that of the benzoic acid, or perhaps it also forms an acid modified differently from what it was at first, as the tartareous acid also does.

This pulverulent mucous acid has very little solubility in water, and that liquid, when boiling, hardly takes up from it more than two or three hundredths of its weight; boiling water does not take up one half more, and nevertheless it is deposited by cooling in brilliant filaments which become white in the air. At the heat of boiling water it decomposes the carbonates. It forms with pot-ash a salt soluble in eight parts of hot water, crystallizable by refrigeration. The mucite of soda is equally crystallizable, and requires only five parts of water to dissolve it: these two salts are much more soluble by an excess of their acid or of their bases. The mucite of ammonia is little known; it loses its base by the action of heat. We do not yet
know

know the combination of the mucous acid with the other bases; we only know that the mucites of barites of lime and of magnesia are nearly insoluble. This acid decomposes the nitrate and the muriate of lime, as well as the muriate of barites.

The mucous acid acts but very feebly upon the metals; it appears to form with their oxides salts of little solubility. It precipitates the nitrates of silver, of lead, and of mercury.

The composition and the proportions of its principles have not yet been determined; we only perceive that it contains a large quantity of carbon; and that in proportion as it is formed by the change of the equilibrium of the component parts of the gums that yield the most of it, a change effected by the action of the nitric acid, the remaining part of this body is sensibly less carbonated. Citizen Vauquelin and myself have found, in our experiments upon this object, that 100 parts of gum yield from 0,14 to 0,26 of mucous acid; that the nitric acid does not change the nature of this acid; that we may cause it to boil for a long time without its being altered; that it is deposited after cooling in the constant form of a white powder. None of our experiments have shown us, as Mr. Hermstaedt has supposed, that this acid is an oxalate of lime combined with a fatty matter: all our researches, on the contrary, have shown us, that it is a particular acid formed in the first period of the action of the nitric acid upon the insipid gummy and mucic-

luginous vegetable substances. According to this, it is very evident that the name of saccharic acid does not suit it.

13. With respect to the nitric acid, after its first re-action upon the mucus has converted it in part into the acid, which I have just described, if we examine the liquor, we find that it contains a second acid, entirely different from the first, of a dense liquid consistence, very sour, very soluble, which Scheele first observed to be formed by the action of the nitric acid, and which he termed malic acid. This second acid, which holds the middle place, with respect to the period of its formation, between the mucous and the oxalic, does not exist but when the nitric acid has not been boiled for a long time, or when it has not been employed in a large quantity, or too much concentrated upon the gum. It is not certainly obtained, except after the first effervescence which I have indicated: it exists also in the mother water of the oxalic acid. It is easily converted into the latter acid, by the successive action of the nitric acid. Citizen Vauquelin and myself had at first believed that this acid was different from the malic: I propose to term it the *oxalous* acid, because it precedes the oxalic acid in its formation, and as it appears to me to differ from it only by a little more combustible matter, and especially carbon, in its radical. The following are the characteristic properties which we have found in it. Its taste has much analogy with that of lemon juice; it has no colour, but it easily becomes red and
brown

brown by the progress of evaporation. It is easily decomposed and reduced into coal by the action of the fire. It is very soluble in water, and cannot assume the solid and crystalline form. It easily dissolves in alcohol, and does not crystallize even by the evaporation of this volatile solvent. It precipitates lime-water, and forms with it a calcareous salt, soluble in an excess of its acid, a property which already distinguishes it from the oxalic acid, the combination of which with lime does not dissolve in its own acid. This earthy salt dissolves abundantly in boiling water, forms a solution of a reddish-brown colour, which precipitates by cooling in the form of ductile, and as it were resinous flakes; these flakes, again become brittle by desiccation. With barites it constitutes a salt that has little solubility, except in its own acid. These salts are decomposed by the sulphuric acid. The oxalic acid itself also decomposes the calcareous salt described, a proof that the acid indicated is very different from the first. One of its most distinct and most remarkable properties is, that the nitric acid and the oxygenated muriatic acid speedily convert it into oxalic acid. In this conversion nitrous gas and carbonic acid are disengaged. It takes place when we continue to heat nitric acid upon the gum. By this we see that the oxidation preceding that of the oxalic acid, and the succeeding it only by the fixation of a larger proportion of oxygen, it is to the oxalic acid nearly

nearly what the sulphureous acid is to the sulphuric, excepting that it loses also a portion of its radical. But by comparing these properties with those of the malic acid, we found it to be perfectly identical with that acid.

19. What is most singular and most remarkable in the formation of the mucous and the malic acids, in gum treated by the nitric acid, is their almost simultaneous creation. In fact, it is very difficult to conceive why the nature of this body is not equally changed throughout the whole of its mass; why a part becomes mucous acid, and another part malic acid at the same time; why it thus divides itself into two different substances, and by what astonishing mechanism, by what complicated attraction these two compounds are formed at the same time. For the rest, this character of being divided into two, and sometimes three products, is found in most of the organic materials altered or decomposed by any re-agent, by whatever cause this may be. From 100 parts of gum Arabic we have generally obtained 0,24 of malic acid.

20. When, instead of stopping the action of the nitric acid after the first effervescence, or at the period when the malic acid is formed, we continue the application of the heat, and disengage more nitrous gas and carbonic acid; the last mentioned and second acid formed, passes into the state of crystallizable oxalic acid, decomposing all the calcareous salts, on account of
its

its great attraction for lime. As this latter acid exists ready formed in many vegetables, as I shall consider it more particularly in one of the subsequent articles, amongst the immediate materials of vegetables, I only indicate it in this place. I shall only add to this general indication, that after having made it to crystallize, there remains in the last liquor, in the kind of mother-water, which no longer crystallizes, a portion of malic acid above described; but that, by treating the last mentioned liquor again with a new dose of nitric acid, we may change it entirely into oxalic acid.

21. One of the most astonishing facts amongst the discoveries of modern chemistry is, the conversion of gum, or mucilage, into five different acids, according to the manner in which it is treated. In fact, fire develops in it pyromucous acid; the action of the sulphuric and muriatic acids forms acetous acid; that of the nitric acid constantly changes it, in part, into mucous acid, and afterwards, in part, into malic acid, if we do not push its action far, or if we augment it into oxalic acid. Though analogous phenomena present themselves also in several other immediate materials of vegetables, of which I shall speak hereafter, the gum, which presents them the most easily and the most constantly, announces, as we see, in its nature and composition, changes which the pneumatic doctrine alone will be able to determine; for it is evident, from what has hitherto been said, that

that all the causes of these changes have not been exactly discovered or appreciated.

22. It is to the same disposition to change its nature and yield products of very various kinds, that we are to ascribe an effect observed by Mr. Woulfe, and indicated in the *Journal de Physique*, 1788. He observed, that when gums were distilled with fixed alkali, much more oil was obtained than when they were heated by themselves, and that they swelled considerably during this operation. This phenomenon depends only upon the attraction which the alkali exercises upon the pyromucous acid, the manner in which it fixes and retains it, and that in which it determines its decomposition by the action of a violent fire. The carbon and the oxygen then unite together, and the hydrogen united with a portion of carbon, forms oil which is disengaged, while alone it yields a large quantity of water, and scarce any oil: in the same manner the acetous acid, distilled alone, is entirely volatilized, but yields oil when it is heated in union with the alkalis.

23. There is no well-determined action between mucus and the salts. It is easy to imagine that when it is strongly heated with the sulphates, its hydrogen and its carbon must decompose these salts, and convert them into sulphurets; that the nitrates must also burn it, destroy it completely, and present, after this combustion, only its most fixed parts; that thus the nitrate of pot-ash may be employed in order to ascertain

ascertain the quantity of earth and the fixed salts contained in this matter. The super-oxygenated muriate produces this effect in a still more marked manner; it inflames the mucus, and burns it by mere pressure. A mixture of two parts of this salt and one part of gum, in the state of fine powder, detonates by percussion, and produces as much noise, and even more than that of the simple combustible bodies. There is reason to believe that this decomposition may hereafter serve to determine the proportion of the first component principles of mucus, as well those of the other immediate materials of vegetables.

24. The metallic oxides most charged with oxygen, and adhering least to this principle, may likewise serve to decompose mucus by burning it, like those of silver and mercury; this action has not been sufficiently examined, nor has by any means all the advantage been derived from them which they may afford for this kind of analysis. The same is the case with the metallic solutions; it has been remarked that they produce a precipitate in the solutions of gums; that this flaky and viscous precipitate carries with it the oxides, and becomes coloured with different tinges, according to the nature of these; that in general these oxides approach to the metallic state. But it has not yet been determined, with exactness, what takes place in these precipitations, what kind of attraction the mucus experiences, whether it is changed at the same time
as

as it is precipitated; or whether the change, supposing it to take place, does not happen only a more or less long time after the precipitation.

25 From all the chemical phenomena which mucus presents with the different agents of which I have just given an account, and especially from the comparison of the action of fire, and of the acids, it must be concluded that this body is a kind of oxide of hydrogen and carbon, in a state of triple combination, sufficiently solid not to be destroyed but by a violent action, which remains a long time in a state of equilibrium, and which is one of the first formed by vegetation, which costs the least, as it were to the vegetable organization, and is consequently found in most of the organs of plants. Citizen Vauquelin and myself have found, in our investigations of the vegetable substances, that 100 parts of gum contain 23,08 of carbon, 11,54 of hydrogen, and 65,38 of oxygen.

E. *Species or Varieties of Mucus.*

26. Three species of gum employed in different uses are especially distinguished, the gum of the country, gum Arabic, and gum tragacanth.

A. The gum of the country flows from the apricot, the plum, the cherry, the peach, the almond-tree, &c. and in general from all the stone-fruit trees. It is white, yellow, or reddish;

dish ; and when it is well chosen it may be used in place of gum Arabic, over which it has the advantage of being cheaper. I have collected upon the bark of the elm a juice of an orange or red colour, in concrete round tears, of an insipid taste, soluble in water, and forming a viscid solution ; it is a gummy matter, which is not sufficiently abundant to be collected with advantage.

B. The gum Arabic flows from the acacia, the same which forms the extractive juice inspissated by the fire ; this tree, termed *mimosa nilotica*, is very abundant in Egypt, in Arabia, upon the banks of the Nile, and in a great number of places in Africa in general. The gum hangs to the tree in masses roundish, irregular, transparent, white, yellow, or reddish, frequently furrowed, sometimes twisted. The finest is the most colourless and limpid : and is used as food by the inhabitants of the country. It is sometimes called in commerce *Gum of Senegal* : the tears are separated according to their beauty and their purity, in order to distinguish the different qualities.

C. Gum tragacanth is especially obtained from the shrub so abundant in Crete, termed *adragant*, *astragalus tragacantha* of Linnæus. It differs from the two preceding in its form ; it is in ribbands, or in plates, or in blades contorted, striated, canulated ; of an opaque white colour : it is also found in small tears of the same colour. Its solution is much more difficult
and

and more viscid than that of the gum Arabic, it always contains mucilaginous filaments, or flakes; it is employed as more pure and more useful than the latter.

27. Amongst the numerous plants which contain the mucous juice, either in a gluey or pulverent state, the roots of the mallow, and the bulbs of the lilly, the seed of flax, of the quince, are chiefly chosen for extracting the mucilages in common use; they are put to macerate in hot water, and thus are formed viscous, gluey liquids, which supply the place of the gums properly so called, and which may even be brought to the gummy state by desiccation. Every country has besides such a great number of plants which may furnish mucilages by their maceration in water, that it would be difficult, and useless also, here to present their enumeration.

F. *Uses.*

28. Mucus forms in general one of the vegetable materials which nature has best disposed to serve as nutriment to animals. I have observed, that the Africans live upon the gum of the acacia. I shall only observe, that none but strong and vigorous stomachs can easily digest this insipid and viscid juice, and convert it with facility into chyle. An European, who travels in countries where gum is produced, ought not to make use of it without some kind of seasoning

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ing, and much precaution: for the same reason the food best appropriated to man, amongst the vegetable matters, is a mixture or a combination of mucous juice and sugar.

29. In the art of healing, all the gums and all the mucilages are employed with great success as emollients, relaxing, strengthening, for quieting irritation, inflammatory heat, and pain; their chief use is in topical or external applications to painful inflamed tumors, which show signs of commencing resolution or suppuration. This is the reason why the mucilages of lint-feed, quince-feed, mallows, the lily-root, are made to enter into the mixtures of cataplasms, that are termed sedative, resolvent, or emollient.

30. In the arts much use is made of gums or mucilages, to give consistence to slight piece-goods, and to the colours which are applied over them, and sometimes to glue or cause the surfaces of these bodies to adhere together. Paper and cloths are sized by the solution of gums. They are employed in order to give body and gloss to felts, ribbands, and taffetas. Stuffs dipped in gum-water assume a transient gloss, and lustre, which is very quickly destroyed by the contact of water. It is also made the base of the blacking for shoes and boots. Gum enters into the fabrication of ink. In a word, the gums and mucilages are very useful in domestic and manufacturing economy.

ARTICLE VI.

Of the third of the immediate Materials of Vegetables, the Saccharine Mucous Substance, or Sugar.

A. Seat.

1. THOUGH some chemists have nearly confounded mucilage and sugar with each other, and though the latter substance has been called pretty generally *saccharine mucous matter*; though in fact the saccharine has great relation with the mucous matter, it is no less certain that there exists between these two substances certain differences so essential that it is impossible to confound them, and that render it necessary to treat of them separately. Sugar, or the saccharine matter exists in abundance in vegetables. It may even be said, that there is scarcely any part of plants which is wholly deprived of it: but we ought here to speak only of those which contain a sufficient quantity of it for it to be very perceptible by its taste, for it to be impossible to doubt of its presence, and for this part to be frequently even employed instead of sugar, or sugar to be extracted from it more or less pure.

2. This

2. This substance is found very frequently in roots. Besides the well-known saccharine nature of liquorice, sugar exists also in sufficient abundance in carrots, parsnips, turnips, potatoes, onions, to be extracted and obtained separately, as was done by Margraff, by steeping these vegetables in alcohol, which dissolves the sugar without affecting the mucilages and the extracts. It is generally known that the saccharine state of these roots is developed by the action of fire in decoction. It is also known that there are some of these parts which contain it in sufficient abundance to be fit for use as an aliment. Such is that which Sparmann so happily discovered in the interior of Africa, which served him for food during part of his journey.

3. The stems are frequently filled with saccharine juice. Besides the sap of the birch, and especially that of the maple, from which sugar is extracted in America, the pith of some palm-trees, that of the bamboo, that of various reeds, the stalk of maize, and especially that of the *saccharum officinale*, contain it more or less abundantly. It is the last mentioned plant which, having been transported from Africa into America, because the most abounding in this product, furnishes all Europe with the sugar which is consumed in such large quantities, and has become an article almost of the first necessity to a portion of the inhabitants of this part of the world.

4. There are many vegetables whose leaves are saccharine, and many of them exude a thick juice in small drops, which thickens and becomes concrete at their surface in the form of small grains or saccharine powder. Such is the manna that proceeds from the ash, the larch, the alhagi. Such is the dew which covers the surface of the leaves of the lime, of the elm, and many other trees with a brilliant and saccharine varnish in hot and dry seasons. This excretion is even considered as a kind of disease of the trees. It is certain that the leaves are in general those parts of vegetables which have the least of the saccharine taste; it seems even that this juice, when it exists in them, is displaced out of its natural situation, and as it were by an error of place.

5. On the other hand, there is not perhaps a single flower which is entirely destitute of saccharine juice. A great number possess even a particular organ, the nectary, in which this juice is accumulated and deposited under the name of *nectar*. It exists there at first in thick transparent drops: it afterwards becomes thicker, and assumes even the granulated and solid form. It is this nectar, which is at the same time both aromatic and saccharine, which the bees collect, and which they convert into honey, a substance very analogous to sugar, which the ancients used, as the moderns have employed the latter substance since the discovery of America. But no flower or leaf contains a sufficient quan-

tity of sugar for it to be extracted with advantage.

6. The fruits are one of the parts of vegetables in which the saccharine matter is most abundant. The juice which fills them, the pulp which is inclosed in them, or the flesh, the more or less solid parenchyma which forms their texture, are so saccharine, that it must have occurred to the minds of many men to attempt to extract sugar from them; and it cannot be doubted that this art may be established at some future period with success in hot countries, if the advantage of the cultivation of the sugarcane should be lost or diminished by any cause: it is known that plums, apples, and figs more especially, are so charged with it, that by drying these fruits in a stove, a considerable quantity separates from all their points in grains or in powder.

7. The seeds, on the contrary, are perhaps those vegetable parts which contain the least of the saccharine matter: but most of them have the very remarkable property of becoming saccharine by germination. This phenomenon, which is very sensible, especially in the cereal or the graminaceous seeds, gives rise to many arts, especially that of brewing. The formation itself, or this conversion of an insipid or mucous vegetable substance into saccharine matter, is one of the facts which must throw the greatest light upon the difference or the relation of these two substances, as I shall soon show: it is
analogous

analogous to what happens in a particular species of fermentation, which I shall distinguish hereafter, and to what takes place in the maturation of fruits, in which we cannot fail to recognize the production of sugar by an intimate action of the vegetable materials.

8. Notwithstanding this multiplicity of places in which we meet with the saccharine matter in vegetables, it is to be remarked that it is nowhere pure, that it is mixed or combined with mucus, with acid, with different kinds of fecula, with extracts, with colouring matters; in a word, that it is not with this substance as with gum or mucus, which frequently exists insulated, so that it may easily be extracted or obtained in a separate state.

B. *Extraction.*

9. It is on account of this mixture or combination with so many different matters, and sometimes with several together, that in order to obtain sugar properly so called, and in the form known to every one, it is not sufficient merely to press the vegetables which contain the saccharine juice of which it forms part; but it is also necessary to prepare these juices by processes more or less tedious and expensive, to purify them, to separate from them the fecula, the mucus, and the colouring matter. Two vegetable substances, namely the juice or sap of two or three species of maple, and that of the sugar-cane

cane cultivated in America, *arundo saccharifera*, *saccharum officinale*, are those which afford it the most abundantly, the most pure, and with the least labour; though these laborious operations constitute an art no less complicated than important.

10. In Canada, and in some of the states of North America, the sappy juice of the maple is made to run out by several holes bored in the tree at different heights. In the spring, by placing snow at the foot of the trees at the close of the night, the flow of this sweet sap through the orifices made in the maple trees, is increased by the contraction thus produced. This sap is boiled in proper vessels till it has acquired the requisite consistence to suffer the sugar to crystallize by cooling; and though this art has not yet been well described, which it would be useful to multiply and establish in all the countries in which the maple is so abundant, it is highly probable that the processes of which it consists are similar to those which are practised upon the juice of the sugar-cane.

11. In the South American colonies, in the islands where the sugar-cane is cultivated in great abundance, the stem, when ripe and sufficiently yellow, is crushed between cylinders; the juice which runs out is received into an hollow table placed under the cylinders, and termed *melasses*; the cane thus exhausted is employed as fuel. The syrup which is more or less rich in sugar according to the maturity of
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of the cane, the soil in which it has been reared, and the state of the atmosphere that has prevailed during its vegetation, is put into kettles in which it is boiled with wood-ashes and lime. The liquor is carefully skimmed; when it is sufficiently condensed, or in the state of syrup, it is boiled with lime and alum; it is afterwards poured into a back or *cooler*; it is stirred with a wooden spatula; the crust which forms at its surface is broken; it is distributed into shallow wooden vessels in order to accelerate its cooling; it is poured still luke-warm into casks placed upright over a cistern, and perforated at the bottom with several holes stopped with canes. The juice concretes like a salt that crystallizes; and the liquid portion or syrup into the cistern. The sugar obtained by this first operation is termed *moscovado*; it is yellow, soft, and as it were fatty.

12. This *moscovado*, or raw sugar, is purified or refined in the same places by the following process: it is boiled into a syrup with a little water; this syrup is poured hot into cones of baked earth, or moulds perforated at their lower extremity with a hole, which at first is kept stopped. Each of these cones is placed inverted upon an earthen pot which receives the open point, and serves to keep it in a vertical position; the syrup is first stirred in these cones, and afterwards is suffered to cool and crystallize. After it has been left to stand for fifteen or sixteen hours, the perforated point of the cones is opened, and the

the portion of the fugar that has not become concrete is suffered to run out in *coarse syrup*; the base of the concrete fugar-loaves is scraped; while pulverized fugar is put in, beaten down, and covered with a layer of clay mixed with water: this water filtrating gradually through the particles of the fugar-loaf, separates from it the soft brown portion, which is more soluble than the well-crystallized part; this runs out, carrying with it the *fine syrup*. This operation of claying is several times repeated; the whitened loaves are then taken out, they are dried in a stove for eight or ten days; they are broken, and reduced into large fragments, which are termed *cassnades*, and sent to Europe.

13. This operation, of which I here give only an imperfect sketch, has not yet been brought to its perfection. Hitherto there have been no able chemists who have had the means of occupying themselves with this subject in the islands; some have just began to attend to it, and at periods when it was not in their power to apply the new discoveries to this work. It is more than probable that a portion of the fugar is burned in the boilers in which the syrup is boiled, and that the evaporation ought to be performed with less fire. What takes place in the boiling is not yet known. Some think that it serves to separate a fecula, an extract, and a colouring matter; to this they think that the ashes and lime contribute; others assert, and Bergman was of this opinion, that the active
re-agents

re-agents serve to separate a portion of acid that exists ready formed in the cane-juice, or which the fire required for the evaporation has developed in it. Some imagine that it is only a simple evaporation and the action of the fire, which on the one hand diminish the quantity of the water, and condense the particles of the sugar, and on the other coagulate and separate the fecula from the colouring matter. All this uncertainty cannot be dissipated, and the operation cannot be known and rectified till men instructed in the present state of chemistry shall observe and examine this operation, upon the place itself, and in all its details. The analysis of the cane-juice will be an indispensable preliminary of this excellent and useful work.

14. In Europe the cassonades are refined by a process which resembles the last boiling of the sugar. This refining consists in dissolving the cassonade in water charged with lime, and adding to it ox-blood, size, or white of egg, in order to clarify it. The liquor is boiled, the fire is afterwards slackened, the scum carefully removed, the syrup concentrated by a brisk fire, and the rising checked by throwing a little butter upon the liquid. When the boiling is completed, the fire is extinguished; the liquid is poured into earthen moulds, then stirred and suffered to cool; the hole of the moulds is opened; the base of the sugar-loaves is clayed with wet argil, and this claying is repeated till the water has carried away all the syrup. and the sugar is sufficiently

sufficiently white; the loaves are dried in a stove heated to 40° of Reaumur: they are left eight days in this stove, and afterwards put in paper fastened with packthread. According to the nature of the cañonades which we treat, we obtain refined sugar, pure, and more or less white. The theory of this operation is not more advanced than that of the boiling of sugar, and the observations which I have made upon the latter apply equally to the refining process.

C. Physical Properties.

18. SUGAR is not only solid like a great number of the immediate materials of vegetables; but it is formed of a great number of crystalline grains more or less brilliant, and is itself capable of assuming a regular polyhedral form. When it is made to crystallize in the state of sugar-candy, or when it crystallizes in liquors which are saturated with it, such as the syrups, it is obtained in cuneiform octahedrons, imperfect at their two summits, each of which is replaced by a rectangle, or in hexahedral prisms terminated by summits of two faces. This property, together with its taste, have caused it to be considered as a kind of saline substance, and many chemists have considered it as holding the middle place between mucilages and essential salts.

16. On account of its saccharine and agreeable taste, it is distinguished and relished by
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many animals, and even by the carnivorous; it is so peculiar to it, and characterizes it so well, that there is only this single substance amongst all the products of nature which enjoys it, and it certainly depends upon its kind of combination, and the particular proportion of its principles. Sugar has no kind of odour, though insects are attracted from a distance by its presence: it is white and transparent, or colourless.

17. It is one of those natural bodies which possess the phosphoric property in the most marked manner. When it is rubbed or grated in the dark, it diffuses luminous streaks extremely brilliant, and which pass with the rapidity of lightning. It appears that the caloric, expelled from between the particles of this body thus rubbed and evidently compressed, is disengaged with the accelerated motion which gives it the form of light.

18. Every one knows the extreme brittleness of sugar; but it has not yet been sufficiently noticed that it is capable of varying in a remarkable manner, and that the density of this body may have a great number of different states. Sometimes it is very hard, and does not break without difficulty. That which is well crystallized and candied has the vitreous fracture; that which has congealed speedily is granulated. We meet with specimens which, in this last mentioned state, are very tenacious, and cannot be broken in pieces without difficulty. Other pieces crumble with the greatest ease. The first
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owes its strong consistence to a rapid crystallization, and a great degree of dryness. The degree of softness in the second depends upon the water which it retains between its particles, or which it has absorbed.

D. Chemical Properties.

19. VERY striking relations subsist between the chemical properties of mucus and those of sugar. But, though these analogies are so strong and so multiplied, that chemists would frequently be at a loss to distinguish the products of the one from the other, yet there are some particular characters, some phenomena produced by various re-agents, which establish differences sufficiently remarkable. I shall rapidly pass over the similar properties, which I shall merely indicate, and shall dwell more particularly upon those which establish distinctions considerably marked between these two bodies.

20. Under the action of fire, the habitudes of sugar are little different from those of mucus; when heated in contact with the air, it is fused more quickly, it is more softened, and is coloured and decomposed more speedily than gum is; it also exhales a more agreeable and more odorous vapour, and leaves a more spongy and more dilated coal than that of mucus. Every one knows that sugar, treated in this manner, is fused, swells, and diffuses a strong and agreeable smell, known by the name of *Caramel*. If we do not urge
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this decomposition by an open fire so far as to reduce the sugar to a coal, it remains brown, adhesive, deliquescent, of an acrid pungent taste, a little empyreumatic, and very acid. When distilled in a retort carefully and slowly, by means of a well-graduated fire, it affords more water than gum, still less oil, more pyromucous acid, less carbonic acid, and carbonated hydrogen gas; and its coal, which is less dense, lighter, and more easy to be incinerated, leaves a little more pot-ash and lime in its residue. These phenomena indicate a larger quantity of oxygen, and in general a proportion somewhat different between its primitive principles. This is also the true cause of all the different gradations that will be described in its properties.

21. Sugar is no less unalterable by the air than the gums; it is only capable of absorbing a little humidity from it, by an hygrometric effect; it exactly follows all the states of the atmosphere when exposed to it. Accordingly, in order to preserve it, care must be taken to keep it in a warm and dry place, defended against the vicissitudes of the weather. It dissolves in water, with which it forms, when well saturated with it, a ropy, viscous liquor, unalterable when pure, and called *syrup*. The solution, evaporated slowly and spontaneously by the contact of hot and dry air, crystallizes; and in this manner it is that sugar-candy is made. If the syrup at the same time contains some other matter in solution,

tion, it passes into the vinous fermentation, and forms alcohol, of which I shall speak in detail in the order of facts in which I shall treat of the spontaneous alterations of vegetables. Hot and especially boiling water takes up more sugar in solution than cold water, and forms a liquid more dense and more tenacious than syrup. As this kind of solution or softening by means of heat may have several different degrees of density, and become more or less strongly solid or concrete by cooling, great advantages are derived from this very diversity of its properties in the art of the confectioner; and these different states of solution, more or less dense and concrescible, constitute the different degrees of the boiling of sugar, used in frosting of confectionary, or comfits, &c.

22. Though there are certain analogies between the manner in which the powerful acids act upon mucus and upon sugar, they do not extend as far as chemical authors have carried them, but there exist between them very remarkable differences. The concentrated sulphuric acid reduces it to a coal, converts it in part into water as it does gum; but the nitric acid never converts it into mucous or sacchlaric acid, as it does gum; the sugar passes at once and immediately (under the same circumstances in which gum forms pulverulent and insoluble mucous acid) into the state of malic acid, and afterwards quickly into that of oxalic acid, by the continued action of the nitric acid. It is also
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of all the vegetable substances that which yields this last crystallizable acid the most easily. But it always furnishes a portion of malic acid at the same time, and there always remains a more or less abundant portion of the latter in the mother water of the saccharine oxalic acid, or that obtained from sugar, when this mother-water can no longer furnish crystals. This very remarkable difference, this property of not affording insoluble mucous acid, and of passing immediately and at first into the state of malic acid, and afterwards very quickly into the state of oxalic acid, has appeared to Citizen Vauquelin and myself to depend upon the more oxygenated nature of sugar than of gum. It is too much furcharged with this principle; it is too near to the general state of acid, to be able to form the highly carbonated and very insoluble mucous acid, to be able to pass through this first degree of inferior acidification. Accordingly, as soon as the nitric acid acts upon it, and changes the order of its composition, it is not divided into the two first acids, the mucous and the malic, but into the two following, the malic and the oxalic. The less the acid of nitre has acted, the more the proportion of malic acid exceeds that of the oxalic, though there is always a little of this formed from the commencement of the action of the nitric acid. We here see the division of the sugar into new bodies, a division which invariably characterizes the vegetable substances.

23. Sugar comports itself nearly in the same manner

manner as gum with the alkalis, which cause more oil to be obtained from it by distillation; and also with the nitrate of pot-ash, which burns its hydrogen and carbon, and insulates the fixed matters; with the super-oxygenated muriate of pot-ash, which inflames and detonates strongly with it by percussion; with the metallic oxides which burn or decompose it; and with the solutions of the metals, which also precipitate it from its solution, and alter it.

24. By the aid of all the means which alter and decompose sugar, we may determine the proportions of its primitive principles, the relative quantities of oxygen, of carbon, and of hydrogen which constitute it. Lavoisier, by using the vinous fermentation, which it alone is capable of undergoing, and which consists in a spontaneous decomposition, and in the division into two new compounds, which I have already so frequently described in the vegetable substances, has found that one hundred parts of sugar contain sixty-four parts of hydrogen, twenty-eight parts of carbon, and eight parts of oxygen. Though it appears that this analysis has not yet been able to receive all that degree of precision which it would be possible to give it at the present day, if we should compare the different results afforded by the different means of decomposition, yet this first datum of Lavoisier, which is not far remote from the truth, shows that sugar is an oxide of carbon and hydrogen, a little more oxygenated than gum, and that it

is in this that its difference consists. It appears, that the conversion of insipid mucus into saccharine matter is effected in vegetables by mere oxygenation, and by a slight change of proportion in the principles. It is not improbable that art will hereafter be able to convert the gums into saccharine matter; and I have already several times observed, that a solution of gum in water, into which oxygenated muriatic acid gas was made to enter, assumed a saccharine taste, mixed indeed with a strong bitterness. This prospect which is still very new, must lead to many useful researches and results. It is already acknowledged by some modern chemists, that the mucous and feculent vegetable substances are frequently converted in the stomach, by the process of digestion, into saccharine matter; and it is in this manner that Messrs. Rollo and Cruickshank believe the diabetes mellitus to be produced.

E. Species or Varieties of Sugar.

25. We have already seen that the saccharine matter is never pure and insulated in vegetables, as mucus so often is; that it is united sometimes with mucilage, sometimes with fecula, or extractive, and one or more colouring matters, and when we wish to have it pure, we are obliged to employ different means in order to separate it from these foreign bodies; there are, however, some saccharine substances, which are used
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impure, and such as nature presents them. Hence it results, that four principal species of saccharine substances, more or less in use for the common purposes of life, are to be distinguished; namely, sugar, properly so called, the sugar of the maple, honey, and manna. Though some saccharine fruits are used in several countries, as substitutes for one or other of those substances, they are only to be considered as very imperfect mixtures.

A. I have already spoken of sugar, properly so called, because it is the purest saccharine product, that which is the most abundant, and the most employed in Europe. It has served in some measure as a representative of the whole genus. It is known that it is derived from the pith or medullary and utricular juice, of a gigantic species of the gramineous plants; that it requires much labour to bring it to its crystalline and pure state; that it is not yet even well known in what its preparation and its purification consist, which have not yet been brought to the point of perfection, which may be expected from the present state of chemistry. This sugar is employed in different states of purity from the muscovado and the raw sugar, the different kinds of cassonade, the common or officinal sugar in large loaves, the white and very crystalline sugar in small loaves, the double-refined hard sugar, very close and very brilliant in its texture, and the sugar-candy. The syrup, and molasses are equally applied to a

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great number of uses, especially after they have been purified and bleached by heating and causing them to throw up their skum; by filtrating them through woollen cloths, of a close texture, and slightly boiling them with pulverized charcoal.

B. The sugar extracted from the maple, which in part supplies the consumption of the inhabitants of North America, especially in Canada, forms a second species very nearly approaching to the first in its good qualities, when it is well prepared; it is equally beautiful, equally white, and equally well crystallized with that of America, or that of the sugarcane; but the labour by which it is procured, is still too long and troublesome for its quantity to have been yet raised to the level of the consumption, even in the parts of the world where the tree which affords it is the most abundant; it appears to be most pure in the sap which holds it in solution; it is much more diluted, much more extended with water, and in proportion as its solution is condensed and concentrated, it becomes mucous and coloured. The art of extracting it from the sap of the maple, is yet very far from having been brought to the perfection which it is capable of attaining, when the lights and the instruments of modern chemistry shall have been applied to it. Perhaps this sap might first be graduated or concentrated by congelation, and thus the great labour and expense of its evaporation diminished.

nished. It would first of all be necessary carefully to analyze the sap of the maple.

C. Honey is the only saccharine substance that was employed in antiquity. It has been pretended that the ancients knew, by processes of purification analogous to those that are practised for sugar, to extract from it a solid and concrete matter, capable of being preserved; but there is no historical monument to prove the truth of this assertion, though there is nothing that directly opposes the success of such a labour. It is, however, much more probable, that the ancients, who carefully distinguished the different species of honey, and who used the greatest industry in the keeping of bees, employed different species, according to the uses for which they were destined, and selected for some of these uses, a concrete and granulated species, more or less similar to our sugar, properly so called. Honey is nothing more than the nectar, or the saccharine and aromatic juice which the bees collect from flowers, and which they carry in their nests or hives, for their own subsistence in the cold season, and for that of their young. It especially accompanies the female organs of generation in plants, and is found at the base of the pistils of flowers; generally, it even impregnates the style, which contains it throughout the whole of its continuity, as we perceive by sucking these parts of the flowers. It seems to serve, to fix, and conduct the fecundating effluvia of the pollen. Honey
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is a combination of saccharine matter, and aromatic or odorous mucilage. The mucus substance which it contains gives it viscosity, a kind of glutinous quality, deliquescence, and renders it difficult to be purified.

D. Manna is the fourth species of saccharine matter which I distinguish in this genus. It is a gummous saccharine juice, coloured by a nauseous extractive matter; its taste also is disagreeable and very different from that of sugar, properly so called. It issues spontaneously in small drops, which form solid grains, from the leaves of the pine, the fir, the oak, the juniper-tree, the willow, the fig-tree, the maple, and the olive-tree. It is also seen in the form and by the name of honey-dew, upon the leaves of the elm, the linden, and the yoke-elm, the upper surface of which it covers with a light and polished integument. Lobel and Rondelet have described, by the name of *alcomeli*, that which is found upon the olive-trees, in the vicinity of Montpellier. Tournefort has likewise collected some upon the trees in the neighbourhood of Aix and Toulon. But the trees which furnish the most of this juice, and from which that which is employed in medicine is extracted, are the ash, the larch, and the alhagi.

The ash, which grows in abundance in all the temperate climates, yields, more especially, a large quantity of manna, in Sicily and Calabria. Though the manna collects upon the futures of its leaves, a much larger quantity is obtained
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by making incisions into the tree. The saccharine juice runs out through the apertures, and attaches itself as it dries upon the trunk of the trees, from which it is taken off. When straws or small sticks are placed in the incisions, the manna is formed, by incrusting itself upon them, a kind of stalactites, which are termed *manna in tears*: this is the finest and the purest kind. The fragments which are collected upon the tree itself, and which are irregular, less pure than the first species, form the manna in forts; as to the pieces which fall on the ground, and which are mixed with much filth, they are termed *fat manna* (*manne grasse*), because they consist of impure tears, glued to each other by a brown, viscous, and as it were fatty juice. The ash sometimes yields manna in our southern departments. Citizen Chaptal has seen some which had been collected at Aniane, about two myriameters distance from Montpellier.

The larch, which grows in abundance in the vicinity of Briançon, affords, during the summer, a kind of manna in small grains, which the inhabitants collect upon the sutures of the leaves of this tree, and put into pots, which they keep in cool situations. This kind of manna becomes very yellow, diffuses a disagreeable smell, and has a much more nauseous taste than the manna of the ash.

With respect to that of the Alhagi, it flows from a shrub, a species of genista or broom which grows in Persia, and respecting which Tournefort

fort has given interesting details. It is in the form of small grains, which the heat of the sun has dried upon the tree. This manna of the Alhagi is sold in the town of Tauris, by the name of *tereniabin*. It is scarcely known or employed in Europe.

Manna boiled in a little water, clarified with the white of egg, and sufficiently condensed, affords real crystals of sugar.

26. It is now asserted, according to the experiments of Mr. Achard, of Berlin, that solid and crystallized sugar may be extracted from the white beet-root, with red veins; that this species of sugar may be substituted in the place of that of the sugar-cane cultivated in America and Africa, and that it may be afforded at a much lower price. The experiments which are repeating in France upon this subject, will soon inform us what we have to think of this application of this already ancient discovery of Margraff.

F. Uses.

57. THE saccharine substance is an aliment much sought after by a great number of animals, and especially by insects. We see most of these, and especially the insects with trunks, assembling about the saccharine juices, attracted even by fragments of solid sugar that have no smell, and eagerly seizing upon it. It is well known how many insects inhabit flowers,
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and derive their nourishment from their necessities. Man also finds in it a part of his subsistence; numerous facts, and especially what happens in the sugar colonies, prove that this substance may serve him in the place of food. However, amongst most cultivated nations, it is used merely as a condiment, but as such its form is extremely varied, and it is employed for very numerous uses. It serves to preserve a multitude of substances, which without it, would be more or less alterable, as is proved by the art of the confectioner. It softens the acrimony, improves the taste, and disguises the insipidity of many vegetable substances or foods. Nature herself has pointed out its use to man, by presenting it to him in a great number of alimentary substances formed by the plants, and by uniting it with the insipid mucilage, the tasteless fecula, the pungent acid, the ambrosiacal aroma, &c.

28. Sugar is also one of the medicinal substances most in use, one of the substances that are the most frequently and the most abundantly administered to the sick. It is particularly ranked amongst the emollients, and the slight bracers, or even the analeptics, the relaxing, or rather the laxative medicines, and the antiseptics. It serves to sweeten all medical draughts; and when we calculate the quantity which the sick generally take of it, we find, that it is sufficient to sustain, to nourish, and to support, sometimes more even than is necessary, the strength re-

quisite for the cure of their disorders. If it be ever so little combined with foreign substances, especially those that have a more or less disagreeable or nauseous taste, it becomes purgative, as we see in the different kinds of honey, of manna, and in a great number of the laxative fruits. Its antiseptic and preservative property shows itself even when we cover the flesh of animals, fruits, &c. with a more or less thick layer of this substance in powder. Its agglutinating, and as it were, astringent quality, renders it very fit for curing wounds, or cuts, for stopping slight hemorrhages, by closing the lips of a recent wound, and even diminishing to a certain degree the bad condition and putrescency of old ulcers, &c.

29. Sugar is also employed in the arts for a great number of uses, for giving brilliancy to varnishes, to ink, to paintings, to some slight surfaces; for imparting an agreeable taste to the mouth-glue; for making sticking-plaster; it is the base, or the recipient, of a great number of pharmaceutical preparations, &c.

ARTICLE VII.

Of the fourth of the immediate Materials of Vegetables, or the Vegetable Acids.

SECTION I.

Of these Acids in general, of their nature, their Enumeration, and their Classification.

1. THOUGH we may in general consider, as a single one of the immediate materials of vegetables, that acid, which is so abundantly contained in them; though we may be allowed to believe that this substance, which is so well characterized and so easily known, is, wherever it is met with in plants of their products, one and the same matter differently modified, and possessing some varied distinctive properties according to some slight shade in its composition, which is always the same, always identical,—it is nevertheless difficult to avoid considering as real species those among the vegetable acids that present the greatest differences from one another, whether in the properties which all men distinguish in them, or in the uses more or less remote from each other to which they apply them, according to the very dissimilar qualities which they have observed.

2. It will never be possible to confound the very agreeable acid juice of the lemon, of apples, or of vinegar, with the astringent tartness of nut-galls, and the burning acrimony of the acid extracted from Benzoin. It is true that modern chemistry has been able to approximate, by its learned speculations, and almost to confound by its ingenious experiments, the juice of apples with the acid of sorrel, the acetous acid, &c. ; but it has not yet done the same with all the vegetable acids. Though several of them have already been converted by its powerful means into one another, they have not yet all undergone this species of metamorphosis ; and though we are permitted to hope, either that all these conversions will be effected by future experiments, or that we shall find out the true causes of the failure of these transmutations ; it is no less certain, that in the present state of our knowledge it is necessary carefully to distinguish the different acids which the vegetables present to us.

3. This part of chemistry has made immense progress from the year 1776 to the present day. At the former period scarcely two acids different from each other were distinguished in vegetables, namely, that which was native in them and which was always believed to be a kind of tartar, and that which was the product of fermentation ; and nevertheless, the number of the four plants was found to be immense in the first and most superficial assays of the chemists ;

chemists; the number of those which were obtained in the changes which vegetables were made to undergo by the analytic means to which they were subjected, appeared equally considerable. In the present state of chemistry we reckon at least fifteen species of vegetable acids: the labours of Bergman and Scheele first opened this brilliant career, which many modern chemists have followed with a rapid pace.

4. All these acids of whatsoever kind, artificial or factitious, are composed of analogous principles. We constantly find in them, by exact analysis, carbon, hydrogen and oxygen; they are all reduced by the oxygenating or burning processes into water and carbonic acid. We ought, therefore, to consider them as acids with binary radicals, *hidro-carbonated* or *carbo-hidrogenated*, united with different proportions of oxygen, which differ from the vegetable oxides properly so called, or from the immediate but not acid materials of vegetables, only by their super-abundance of the acidifying principle. In this manner, it will easily be conceived how the oxides are converted into acids, whether by the action of fire, or by that of the decomposable acids with simple radicals, or by fermentation. In this manner also may be explained the reciprocal conversion of several of these acids into one another. In order to effect any of these conversions, it is sufficient to produce a variation in the proportions of the principles which constitute the materials

materials or these acids: almost always we extract from them different quantities of hydrogen or of carbon, or both at the same time, and we augment the quantity of oxygen so as to complete their acidification.

5. When we try the plants which we meet with in our walks, with very sensible blue paper, most of them exhibit marks of acidity; but most of them, when treated with more exactness in their juices, are found to contain several acids at the same time; and it is very rare, perhaps even impossible, to find a single acid in any one part of plants, especially in the juices of acid fruits. The same phenomenon is observed when by treating the different vegetable oxides, and especially mucus, the saccharine matter, the fecula, &c. by the different oxygenating or acidifying processes, we convert them into acids: We obtain from them at least two species, frequently three at a time. In this manner I have converted the ligneous substance into four acids, and I have even found five different species in crude and four wines of the vicinity of Paris. It therefore appears that art imitates the processes of nature in the fabrication of the acids; for there are always several of them together, though I must here remark, that the acids simultaneously presented by Nature in a great number of vegetable substances, are frequently of the class of those which art has hitherto been unable to imitate.

6. In

6. In order to know the numerous species of vegetable acids, for I here comprehend those only which have hydrogen and carbon for their binary radical, and not the acids with simple radicals, the sulphuric, the nitric, the carbonic, which are frequently found combined in the vegetable substances; it is necessary to admit a methodical division between them, a classification which enables us to compare them, regularly to explain their distinctive characters, their analogies and their differences. With this intention I distinguish them into six genera.

In the first I comprehend the native vegetable acids, which exist pure and uncombined in plants: this genus includes five species, viz. the gallic, the benzoic, the succinic, the malic, and the citric.

In the second genus I rank the acids partly saturated with pot-ash, which are termed vegetable acidules, and which include two species, the oxalic acidule and the tartarous acidule.

The third genus comprehends the acids formed by the fire, or the empyreumatic; of which there are three species, the pyromucous, the pyrotartarous, and the pyroligneous acids.

To the fourth genus I refer the factitious or artificial acids, which are formed by the action of the oxygenated bodies, or of the powerful acids, upon some of the immediate materials of vegetables, and which have not yet been met with in nature. This genus comprehends three species,

species, viz. the mucous, the camphoric, and the suberic acids.

In the fifth genus I place the artificial acids analogous to the preceding in their factitious oxygen, or produced by art, but which are similar to those which are also found ready formed in nature. This fifth genus contains two or three species, the malic acid, the tartarous acid, concerning which there is some doubt relative to its artificial formation, as I shall show hereafter, and the oxalic acid.

Finally, I form a sixth genus of the vegetable acids produced by fermentation; there are as yet only two species, the acetous and the acetic acids, belonging to this genus, though it is very probable, as I intend to show, that fermentation is capable of producing a greater number of them, which have not yet been examined with sufficient accuracy to enable us to distinguish them as particular species.

SECTION II.

Of the first genus of the Vegetable Acids, or of the native and pure Acids.

1. NOTWITHSTANDING the immense quantity of spontaneously acid plants and vegetables which are found in abundance and in all latitudes, chemists, in examining plants, have

have hitherto found only five sufficiently distinct species, differing from each other. It is not, however, to be imagined that the discoveries are entirely terminated, or that no hopes are to be entertained of discovering hereafter a greater number of them, when the naturally acid vegetables shall have been better examined.

2. Though I indicate this first genus as containing native and pure acids, I do not speak of entirely insulated and purified acids, and this purity is to be understood only as relative to the acids of the second genus which are partly saturated with pot-ash: in fact, these are sufficiently exempt from pot-ash and from saturation; but they are not completely insulated and separated from all foreign matter. They are found mixed with mucilage, with acid juices, with light fecula, with colouring matter; and it is necessary to employ different means in order to obtain them in the state of purity proper for examining their properties and their characters.

3. Of the five species of acids comprehended in this genus, three, the gallic, the benzoic and the succinic may be obtained in a crystalline form by sublimation; a fourth assumes a very regular crystalline form by the evaporation of its solution, namely, the citric acid; the fifth cannot acquire this crystallization, but always remains in a magma; this is the malic acid. It is, therefore evident, that if we knew only

this property we should be able easily to distinguish them from one another; but their exact history will furnish many other characters of distinction between them.

SPECIES I.

Gallic Acid.

A. History, Seat, Extraction, Purification.

1. THE name of gallic acid is applied to that which is extracted from the nut-gall more abundantly than from any other vegetable substance, though it is also contained in the wood and the bark of the oak, of the ash, the willow, in Peruvian-bark, the Simarouba, the pomegranate, sumac, the root of tormentilla and bistort, the cone of the cypress, the shell of the walnut, the stalk of the Iris of the Marshes, &c. Chemists were acquainted with the property which all these substances possess of precipitating the ferruginous salts in the black state, and they attributed it to what they termed their astringent property. Macquer, Lewis, Cartheuser and Gioanetti investigated by some experiments, though without adequate success, the mode of the operation of these substances upon the solutions of iron. Monnet especially announced that the vegetable astringents acted immediately upon metallic iron, and coloured it

it black. Gioanetti discovered that the precipitate of ink was not attractable by the loadstone, and that the iron does not exist in it in the metallic state, as had till then been generally believed.

2. Though these facts ought to have led to the conclusion that the principle in the vegetable astringent substances which precipitated iron in the black form was an acid, the academicians of Dijon were the first who adopted this opinion, in 1772. They showed that the products distilled from the nut-gall blackened the solution of sulphate of iron; that this excrescence yielded with cold water an extract amounting to a twelfth of its weight, that its infusion reddened turnsole and blue paper; that the same principle that precipitated iron in the black state was soluble in the oils, alcohol and ether; that the other acids also dissolved without altering it; that its solution in water precipitated the sulphur of the alkaline sulphurets; that it decomposed the metallic solutions, and coloured their oxides by uniting with them; that it dissolved iron immediately, and reduced silver and gold, after having separated them from their solvents.

3. These approximated details afforded as yet only a general proof of the acid nature of the principle of the nut-gall whereby iron was precipitated in the black state; but they did not furnish the means of extracting and obtaining this acid separately, and ascertaining its

characteristic properties. It is to Scheele that we owe the discovery of this acid, by the process which he published in 1780 for extracting it pure and crystallized. He poured upon one part of gall-nuts bruised or reduced to a coarse powder, six parts of very pure water; he left them to macerate for fifteen days at a temperature between 15 and 20 degrees; he filtrated and placed the liquid in a large vessel of glass or of earth in order to expose it to the air and let it slowly evaporate. A blackness, and a thick, and as it were glutinous, pellicle were formed; very abundant mucous flakes were separated; the solution had no longer a very astringent, but a more sensibly acid taste. After two or three months exposure to the air, Scheele observed upon the sides of the vessel in which the liquor was contained, a brown stratum adhering to the vessel and covered with granulated crystals, brilliant, of a yellowish grey colour: he also found a large quantity of these crystals under the thick pellicle with which the liquid was covered. He then decanted the latter; he poured upon the deposit, the pellicle, and the crystalline crust, alcohol which he heated; this solvent took up all the crystallized acid without affecting the mucilage: he evaporated the alcoholic solution, and thus obtained the pure gallic acid in small crystals as it were granulated, brilliant, and of a slightly yellowish colour. It is by this process that the acid of which I speak was prepared after Scheele, till
another

another manipulation came to be known, which seems to deserve the preference over it.

4. Citizen Deyeux gave, some years after Scheele, a very good Memoir on the Analysis of the Gall-Nut. He particularly discovered, that by heating this excrescence of the oak pounded, slowly and cautiously, in a pretty broad and high glass retort, it sublimes a considerable quantity of crystals, lamellated, brilliant, silvery, considerably large, and which possess all the properties of the same gallic acid. He indicates this process for preparing this acid; but I shall observe that this means, which is much more expeditious than that of Scheele, succeeds only when the operation is conducted with much caution. It is necessary to apply the fire moderately, to take great care not to push its action so far as to disengage the oil, for this carries away and instantaneously dissolves all the crystals that have been sublimed previous to its appearance. With the aid of these precautions, though the fire constantly destroys a portion of the gallic acid, we always obtain a pretty considerable quantity of it, which is very pure, very white, very well crystallized, and in this state undergoes no alteration. We do not find in it, after having extracted it by this process, either extractive or colouring matter which alter it in the process given by Scheele.

B. Physical Properties.

5. THE gallic acid, especially as extracted by the second process, is solid, crystallized in octahedrons with scalenous-triangles, or in brilliant plates, of an acid, pungent, and austere taste, but much less strong and astringent than that of the gall-nut from which it proceeds; which has induced modern chemists to believe that this acid is not the sole cause of the astringency, as was formerly thought; and, in fact, the acid obtained by sublimation has much less of an astringent taste than that which is extracted by mere maceration, according to the process of Scheele. By the latter preparation, instead of having the acid in plates as by sublimation, we obtain the gallic acid in small octahedrons of a yellowish-grey colour.

6. It is very light, and susceptible of being raised into vapour by a gentle heat; it condenses and crystallizes as it cools. In its state of vapour, it has an aromatic smell, pungent, and considerably analogous to that of the benzoic acid. It is quickly fused by the fire, and forms, almost at the moment of its volatilization, a thick liquid mass, brown, swelled, exhaling an odorous smoke, so that there is always a certain quantity of it decomposed. It strongly colours the tincture of Turnsole.

C. Chemical

C. Chemical Properties.

7. THE gallic acid, though volatile at a degree of heat not very considerable, is at the same time easily decomposable, since every time that we sublime it, a part of it is always decomposed. This decomposition is accompanied with a formation and disengagement of water, of an acid liquid, of carbonic acid gas, of carbonated hydrogen gas, and of some drops of brown oil: it leaves a coal in considerable abundance, difficult to be burned and incinerated.

8. This acid is not sensibly alterable by the air; it requires twenty-four parts of cold water, or at twenty degrees, to dissolve it; it crystallizes only by a slow and insensible evaporation: boiling water dissolves a third of its weight. It precipitates from its solution in proportion as it cools, but without a regular form, and disposed only in small grains which do not become white, but remain with their primitive yellow colour. Alcohol dissolves a much larger quantity of it. This liquid when cold takes up one fourth of its weight. When boiling it can hold a quantity of it almost equal to its own; it is precipitated by cooling. When the solution of the gallic acid in water is kept in close vessels, it becomes altered and decomposed, deposits mucous flakes, and the acid is gradually destroyed.

9. It

9. It is not alterable by the combustible bodies; charcoal, over which the boiling solution is passed, whitens it a little. The concentrated sulphuric acid decomposes and carbonates it. The nitric acid changes it into malic and oxalic acids. The oxygenated muriatic acid also alters it in a particular manner which has not yet been sufficiently determined though it would be important to ascertain it.

10. The gallic acid combined with barites, strontian, lime, and magnesia, forms with these bases salts of little solubility, of a fawn-colour, which an excess of their several bases causes to dissolve in water, much more abundantly than they naturally combine with it. Its saline compounds with pot-ash, soda, and ammonia, are not yet sufficiently known, nor have they been sufficiently examined to be well described. We know in general that they have little solubility, and that their generic characters consist only in the precipitation of the metallic solutions into coloured gallates, and especially of those of iron, into a black or dark-blue powder.

11. That property which most distinguishes the gallic acid from all the other vegetable acids, is the great attraction which it exerts upon the metallic oxides; it is so strong that this acid separates them from the greater number of the most powerful acids: the phenomena which the gallic acid, poured into the metallic solutions produces, are extremely various. The more readily the oxides abandon their oxygen, the
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the more alterable they are by the gallic acid. Poured into the solution of gold, it gives it a greenish colour, precipitates from it a brown powder, which is speedily reduced into gold, and covers the solution with a pellicle of gold, well reduced, brilliant, and metallic. Silver is separated in a brown precipitate from its nitric solution, and a light layer of this reduced metal soon covers the surface of the liquor. Mercury is precipitated in an orange-yellow, copper in a brown, bismuth in a lemon-yellow, iron in a black state. The solutions of platina, of zinc, of tin, of cobalt, and of manganese, are not precipitated by the gallic acid; and it may be here remarked in general, that these are precisely the metals which retain most strongly the oxygen necessary for their saturation, and which are not variable in their oxidation; whilst those which are precipitable by this acid, stop, in general, at different degrees of oxidation, retain but feebly the last portion of oxygen which saturates them, and are, in general, separated from their solvents only at their maximum of oxidation.

12. This has been particularly ascertained for the solutions of iron. Mr. Proust has very well proved that such of these solutions as only contain iron little oxidated, which are scarcely coloured and greenish, either yield none, or but very little of a precipitate, little coloured, and violet, or of a deep red; that those, on the contrary, in which the iron is surcharged with oxygen, form

form immediately a very black precipitate; that it would be advantageous in the preparation of the black pigment, the black-dye, or ink, to employ the red, or super-oxygenated sulphate of iron; that it is for want of employing the latter that we are obliged to agitate the stuffs in the air after they have been taken out of the bath, in order to make them absorb the oxygen which favours the combination of the iron with the gallic acid; that it is for the same reason that ink assumes a fine black colour by its exposure to the air; that this oxygenating and blackening effect may be produced at the very moment when the mixtures are made by adding oxygenated muriatic acid to them. Such is the very simple theory of the fabrication of dyeing mixtures, and of ink, which depend, as we see, upon the highly oxidated state of the iron, and its strong union in this state with the gallic acid.

13. The whole account which I have just given of the properties of the gallic acid, proves that it contains the most carbon of all the vegetable acids, as is demonstrated by its colour, the facility with which it is blackened by the action of the fire and of the air, its little spontaneous alterability, the large quantity of coal which it leaves after its solution, that of the carbonic acid which it affords in its decompositions by fire, and by the nitric acid. We might consider it as a kind of carbonous acid, as Citizen Deyeux had conceived it to be, were

we permitted to exclude the hydrogen from its composition. But the presence of the latter principle, which with the carbon constitutes its binary radical, and assimilates it to all the vegetable acids, and besides is demonstrated to exist in it by all the phenomena of its decomposition, opposes the admission of this opinion, which otherwise is ingenious, though not sufficiently exact for the present state of chemical knowledge.

D. *Uses.*

14. THE gallic acid is much employed in dyeing, and in the preparation of ink ; it forms the base of all the black dyes, and all the grounds of this cast, such as the grey, &c. It is never employed in a pure state, but mixed, as it is in the vegetable substances which contain it, with the astringent matter, and especially with tanin. This is the reason why the black colour produced by this acid thus mixed, has a red or purple cast which frequently appears when the black is changed. We may prepare ink much more coloured, much more pure, and less alterable with the purified gallic acid, than with the decoction of gall-nuts. This acid is frequently used in chemistry in order to ascertain and determine the presence, the quantity, and even the state of iron in a great number of substances in solution.

SPECIES II.

*Benzoic Acid.*A. *History, Seat, Extraction, Purification.*

1. OUR first knowledge of the benzoic acid is due to Blaise de Vigenere, who wrote at the beginning of the seventeenth century. He was the first who asserted that by distilling benzoin a crystallized acid salt was obtained in odorant and acrid needles, which have since been termed in pharmacy *Flowers of Benzoin*. Some chemists conceived it to be a modified mineral acid, till the properties that were found in this acid, plainly showed it to be a vegetable acid different from all other acids of this class. Geoffroy announced, in 1738, that it might be extracted by water. Lemery gave a very good process for obtaining it by sublimation. Scheele lastly showed how to separate it from benzoin by means of lime. Mr. Lichtenstein has published observations on the process of Scheele and on several properties of this acid.

2. Benzoin is not the only vegetable substance which affords the benzoic acid; the acid even bears this name only because benzoin is the vegetable substance which is most commonly employed in order to obtain it, and which yields it in great abundance. It is also obtained from
pure

pure storax, from the ordinary styrax, from the balsam of Peru, and the balsam of Tolu, from liquidambar, from vanilla, and even from cinnamon, the distilled water of which deposits it in crystallized needles by cooling and repose: it also exists in the urine of children, frequently even in that of adults, and constantly in the urine of the quadrupeds that live on herbs and hay, especially in that of the camel, the horse, and the cow. There is reason to believe that a great number of vegetables, and even of grasses, contain it more or less abundantly, and that it is from this food that it passes into the urine. Citizen Vauquelin and myself have found strong reasons for suspecting it to exist in the *anthoxantum odoratum*, a herb which is known to impart an aromatic quality to hay. We have found this acid combined with pot-ash and lime in dung hill water, as well as in the urine of the quadrupeds that have been mentioned.

3. In order to obtain it by the most common or most useful process, benzoin, coarsely pulverized, is put into an earthen pot; this vessel is covered with a cone of pasteboard, pasted upon the sides of the pot: the apparatus is placed upon a furnace charged with very little fire, and even of hot ashes. At this heat the benzoic acid sublimes and attaches itself to the sides of the cone, which is taken off and renewed every two hours: this is continued till the sublimed acid begins to be coloured by the oil which immediately succeeds it by the action
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of the fire. Bucquet substituted instead of this apparatus of Lemery, two simple earthen pans, the margins of which were ground, which he luted upon one another, in order to obviate the loss of all that quantity of acid which exhales through the pasteboard sides.

4. In the process of Geoffroy, the pulverized benzoin was digested in hot water, which having been filtrated, yielded, by cooling, needled crystals; but Scheele has observed that by this means only a small quantity was obtained, on account of the incapacity of the water to penetrate the resinous part of benzoin, especially when fused, and which always swims upon the liquid. On account of this inconvenience, after several trials with different alkaline substances, he adopted the following process: one part of quick-lime is taken, which is first diluted with three parts of water: about thirty parts of water are added, which are afterwards mixed gradually, and with a motion capable of properly disposing the substances together, with four parts of benzoin in powder: the whole is then heated over a gentle fire for the space of half an hour, constantly stirring the mixture; it is then removed from the fire, and left to subside for some hours; the clear supernatant liquor is decanted; eight parts of water is poured upon the residuum, it is boiled for half an hour, and mixed with the former lixivium. The liquor is reduced by evaporation to two parts; muriatic acid is poured into it drop by drop, till
a slight

a slight excess has been produced, which forms a pulverulent precipitate of benzoic acid by decomposing the benzoate of lime dissolved in the lixivium; the precipitate is well washed upon a filtre; and if we wish to obtain it in crystals, it is dissolved in five or six times its weight of boiling water; it is filtrated through linen, and the solution having been suffered to cool, deposits long compressed prisms. In this operation, the benzoic acid, separated from the benzoin by the lime, forms calcareous benzoate, which dissolves in the lixivium, and which the muriatic acid decomposes on account of its more powerful attraction for the lime.

5. Though Scheele, when he published this process, necessarily announced that it affords as much acid as sublimation, which had produced him only from 0,08 to 0,10 of the benzoin; notwithstanding the assertion of Spielman, who had made the quantity amount to a quarter of the weight of this balsam; yet Mr. Lichtenstein has pretended, in new Observations, published in Germany since the Memoirs of Scheele, that this operation does not furnish as much acid as sublimation; but there is reason to believe, with Scheele himself, and with Citizen Guyton, that Mr. Lichtenstein, as well as Spielman, reckon into the weight of the benzoic acid, extracted by fire, the impure portion of this salt, soiled by a small quantity of oil, which greatly increases the quantity; so that the process of
Scheele

Scheele is not less deserving of the preference over all the other methods described before him.

6. We have confirmed the excellence of this process, and, in some measure, extended its utility, by proposing to extract the benzoic acid, for chemical and pharmaceutical uses, from the waters of dung-hills, of stables and stalls, by means of the muriatic acid, which decomposes in it the calcareous benzoate, and separates from it the benzoic acid, as in the process of Scheele. This new process will enable us to reap some advantage from a substance that has hitherto been intirely neglected and useless, namely, the urine of quadrupeds. Should it be feared that the acid obtained by this method might have a foreign smell different from that which it ought to have, we may dissolve it in boiling water, filtrate its solution, and suffer it to cool in order to obtain from it the crystallized acid. By repeating this operation twice in succession upon the acid extracted from the dung-hill water, or from urine, we shall almost intirely deprive it of its smell, which, however, is not fetid, but only a little different from that of the acid as extracted from the benzoin. The urine of the buffalo is that which affords the most of this acid.

B. Physical Properties.

7. THE pure benzoic acid is in the form of a light powder, sensibly crystallized, or in fine needles, the form of which is very difficult to be determined on account of their minuteness. It is white and brilliant when sufficiently pure: that which has a yellow or brown tinge, is soiled by a certain quantity of volatile oil. It is not a brittle substance, as its solidity and crystallized form seems to indicate; on the contrary, it is ductile, and, as it were, elastic. When we attempt to pound it, it forms a kind of paste or pulp.

8. Its taste is acrid, pungent, acidulous, hot, and very bitter. It reddens the tincture of turnsole, but not the syrup of violets. It has not a strong smell when cold, though the slight aromatic odour which it diffuses may, however, serve to distinguish and characterize it; but it assumes a very powerful one when heated, and especially when it is volatilized. It is very light, and occupies a large volume, especially when in the form of long needles intermingled with each other in every direction.

9. When exposed to a gentle fire, it becomes liquefied, forms a soft, brown, and slightly inflated mass, which cools into a solid crust, presenting at its surface marks of crystallization in divergent rays. By the action of a more violent fire it sublimes and exhales into the air in a white,
 Vol. VII. S acrid,

acid, irritating smoke, which stimulates the eyes, and produces a discharge of tears; it is also very speedily volatilized when placed upon an ignited coal.

D. Chemical Properties.

10. THE benzoic acid inflames when heated strongly in contact with the air, when approached to an inflamed body, when touched, liquefied with a red-hot iron, or when subjected to the electric commotion. If heated alone in a close apparatus, the greater part is sublimed without alteration; but a portion is decomposed, yields a little acid phlegm, a greater abundance of oil than any other vegetable acid, and especially a much larger quantity of carbonated hydrogen gas than all other bodies of this nature. It leaves merely a trace of coal in the retort. In order the better to decompose it, it is necessary to treat it in a distilling apparatus after having mixed it with sand: by this means we oppose its volatilization, and cause it to undergo a stronger and more lively action of the fire; we then obtain from it much more phlegm, oil, gas, and coal. The proportion of its principles has not yet been exactly determined.

11. It is not sensibly altered by the air; it has been kept twenty years in an open vessel without losing any of its weight. No combustible body alters it; by distilling it with powdered

dered charcoal, it is rectified or refined, and obtained much whiter and better crystallized than before. It is but very little soluble in water. According to Messrs. Wenzel and Lichtenstein, four hundred parts of cold water are required for dissolving one part of this acid, whilst the same quantity of boiling water can dissolve twenty parts of it, nineteen of which separate from it by cooling. Bergman assures us, that boiling water can take up a twenty-fourth part of its own weight, whilst at the medium temperature it can scarcely take up one hundredth. Its hot solution becomes turbid as it cools, and the precipitate thus formed is so abundant that it cannot be filtrated through paper, the pores of which it stops up.

12. The powerful acids act upon the benzoic acid in a very different manner from that in which they act upon most of the other vegetable acids. The concentrated sulphuric acid dissolves it easily and without motion, according to Bergman, who, however, remarks, that part of the sulphuric acid passes to the state of sulphureous acid. We may afterwards separate the benzoic acid unaltered from this solution, by adding water to it.

The nitric acid dissolves it in the same manner, and water likewise separates it from this solution, without its having undergone any decomposition. Citizen Guyton has found that by distilling nitric acid upon the concrete benzoic acid, nitrous gas was not disengaged till

towards the termination of the distillation, and that the acid was then sublimed without alteration. Mr. Hermstaedt however assures us, that by employing concentrated nitric acid, the benzoic acid became fluid, more fixed than it was naturally, and that it assumes the characters of the oxalic tartarous acid: but this result still requires to be confirmed by further experiment. The action of the muriatic and the oxygenated muriatic acid upon this acid is unknown, as are also those of all the other acids.

13. The benzoic acid unites pretty easily with the earthy and alkaline bases. Hitherto the properties of the benzoates, as well as the particular attractions that subsist between their principles, have been described but very briefly. M. Lichtenstein asserts, that it prefers the fixed alkalis, and even ammonia, to the aluminous, magnesian and calcareous earths. According to the observation of Citizen Guyton, it does not appear that he employed the pure and caustic alkalis in his experiments. Bergman indicates the attractions of the benzoic acid in a different manner. According to him, lime separates the alkalis from it, and barites separates the lime; besides it disengages the acid from the carbonates. Mr. Tromsdorf has communicated, in Crell's Annals, a series of experiments upon the benzoates, by which he has ascertained some properties of the earthy or alkaline benzoates. By subjoining to these some facts which I have collected

collected relative to several of these salts, I have presented the most complete account of them that has hitherto been given in the Encyclopedic Dictionary of Chemistry, from which I shall here borrow the principal results.

14. The Benzoate of barites is soluble, crystallizes very well, remains unalterable in the air, is decomposed by fire and the powerful acids.

No experiments have yet been made on the benzoate of strontian.

The calcareous benzoate is considerably soluble in water, much more so in hot than in cold water; it crystallizes by cooling; it frequently assumes the form of dendrites upon the sides of the vessels. The sulphuric, nitric, and muriatic acids decompose it; barites takes from it its acid, with which it precipitates. It is found in considerable abundance in the urine of the herbivorous mammalia.

The benzoate of magnesia is soluble, crystallizable, and a little deliquescent, more decomposable than the preceding salts.

The benzoate of alumine is considerably soluble, crystallizable in dendrites, deliquescent, of a bitter and acerb taste; it is decomposed by the action of fire, and even by most of the vegetable acids.

The benzoate of zircon is not yet known.

The benzoate of pot-ash crystallizes by cooling into small close needles; the drops of its solution, spread upon the sides of the vessels, form

form on them, by cooling and evaporation, dendrites, or herborizations, which indicate its crystallizability. All the acids decompose it; the solution of barites, and of lime, form a precipitate in its solution.

The benzoate of soda is also very crystallizable and soluble; it is not deliquescent like that of pot-ash, according to Bergman. But it is decomposable by the same processes; it sometimes exists native in the urine of herbivorous quadrupeds.

The benzoate of ammonia has also appeared to me to be very soluble and very crystallizable. Like those of all the benzoates, its solution deposits, when it moistens the sides of the vessels, and when it dries upon them, dendrites and herborizations. It is volatile and decomposable by all the acids and all the bases.

15. Mr. Tromsdorf has found, in his experiments, that the benzoic acid did not act upon the metals, but that it united with their oxides.

The benzoate of arsenic assumes, according to him, the form of minute feathers, is soluble in hot water, and crystallizes by cooling. Hitherto we know no benzoates of tungsten, of molybdena, of chrome, of titanium, of uranium, of nickel, of tellurium.

The benzoate of bismuth is formed, like all the other metallic benzoates which Mr. Tromsdorf has begun to examine, by dissolving its oxide in the liquid acid. It affords white

crystals in fine needles by evaporation; fire disengages the acid from its solution, as the powerful acids also do.

The benzoate of cobalt crystallizes in laminæ; it is decomposable by pot-ash, as are all the metallic benzoates.

The white oxide of manganese dissolves well in the liquid benzoic acid. This solution yields small scaly crystals, unalterable in the air, easily soluble in water, but not in alcohol; the alkalis and the alkaline carbonates decompose it.

The benzoic acid easily dissolves the oxide of antimony; the salt which it forms is unalterable by the air, decomposable by fire and by the acids. The benzoic acid does not precipitate the solutions of this oxide in the powerful acids.

The oxide of mercury obtained by the alkalis, unites with the benzoic acid, which, when it is pure, does not precipitate the nitrate of mercury. This benzoate is in the form of a white powder, unalterable by the air, insoluble in water, slightly soluble in alcohol, decomposable by the alkalis and the acids, sublimable with a gentle heat, decomposable by a strong fire, and by sulphur.

Neither tin nor its oxide dissolve in benzoic acid, nor enter into combination with it, according to Mr. Tromsdorf; but by pouring a solution of benzoate of pot-ash into the nitromuriatic solution of tin, we obtain immediately
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a precipitated benzoate of tin, soluble in hot water, decomposable by fire, and not attacked by alcohol. We may form all the metallic benzoates by the same process, and it is even the best manner of preparing them.

The benzoate of lead, according to the same chemist, affords crystals of a shining white colour, soluble in water and in alcohol, which the sulphuric and muriatic acids decompose; which are unalterable by the air, and from which fire disengages the benzoic acid.

The oxide of iron unites easily with the benzoic acid, and dissolves in it; it forms yellowish crystals of a sweet taste, capable of drying and even disappearing in the air, soluble in alcohol, precipitable in the black state by the gallic acid, and into the blue by the prussiates, losing their acid by the action of fire, decomposable by the pure alkalis which take away the acid, and by the acids which separate it from its base.

The oxide of copper, precipitated from its nitrate by the carbonate of soda, combines well with the benzoic acid; it forms with this acid small crystals of a deep green colour, soluble with difficulty in water, and not at all in alcohol, the acid of which is sublimed by the action of fire, and separated by the other acids, and which the alkalis decompose.

The benzoic acid decomposes the nitrate of silver; it unites well with the oxide precipitated from the nitrate of this metal by the carbonate

bonate of soda. The benzoate of silver thus formed is soluble in water, and very little so in alcohol. It is blackened by the contact of light, the acid is volatilized from it by the fire, and the oxide then easily passes into the metallic state.

The oxide of gold also unites, according to Mr. Tromsdorf, with the benzoic acid; the solution of this benzoate of gold yields irregular crystals, soluble in water, insoluble in alcohol, unalterable by the air, decomposable by fire, and easily reducible into brilliant and pure gold during the volatilization of their acid.

The oxide of platina, combined with the benzoic acid, yields small yellowish crystals, unalterable by the contact of the air, soluble in water with difficulty, and absolutely insoluble in alcohol, and leaving a yellowish residuum after the action of the fire.

16. From all the collective facts relative to the chemical properties of the benzoic acid, it follows that this acid differs from the other vegetable acids in the nature and the proportion of the principles of its radical. Its smell, its volatility, its combustibility, its strong solubility in alcohol, its little solubility in water, had caused it formerly to be considered as an oily acid, and induce modern chemists to think that it contains in its composition a large quantity of hydrogen, and that it is by the superabundance of this combustible principle, and by the highly hydrogenated nature of its radical,

dical, that it differs from all the other acidified vegetable compounds. That it is so little alterable by the acids, and by the oxygenated bodies in general, is because it is too volatile for it to be practicable to render the action of these bodies, which requires to be aided by heat, sufficiently durable, or sufficiently strong to effect its decomposition. It eludes it rather by its volatility than by its peculiar nature.

D. *Uses.*

17. If we except its medical administration, which has now become much less frequent than formerly, the benzoic acid is of no use in the arts. It is prepared in pharmacy, and made to enter into some medical prescriptions, in the solid form of electuaries, boluses, pills, with extracts, syrups, &c. but it is rarely administered in the liquid form, on account of its acid and burning taste.

18. It is extracted and purified in chemistry, in order to learn its properties, to subject it to experiments more or less connected, and to examine its combinations. It is, however, one of the acids that are prepared the least frequently, that are met with in the least abundance in the laboratories of chemistry, and which are the most rarely employed in experiments.

SPECIES III.

Succinic Acid.

THE succinic acid, so named, because it is extracted from amber, a bitumen which manifestly has a vegetable origin, belongs really to the vegetable acids: it is a combination of hydrogen, carbon, and oxygen, decomposable in water and carbonic acid, by the action of the fire and the comburant bodies. I here only indicate it, as I shall examine it more in detail in the order of facts relative to the alterations which vegetables are susceptible of experiencing in the earth. I place it in the method which I adopt for the acids, in the series of the gallic and the benzoic, because, like these it is capable of subliming and of crystallizing by sublimation.

SPECIES IV.

*Malic Acid.**A. History, Seat, Extraction.*

1. THE malic acid bears this name because it has been more especially found by Scheele in the juice

juice of apples. It exists also in a great number of fruits; it exists in small quantity, mixed with much citric acid in the fruits of the *vacinium oxycoccos*, of the *vitis idæa*, of the *prunus padus*, of the *solanum dulcamara*, of the *cynosbatus*. It is found in abundance, and with very little citric acid, in the barberry, the elder, the plum; nearly equal parts of both acids are extracted from the currant, the blackberry, the *cratægus aria*, the cherry, the raspberry, the strawberry. These are the results of the fine experiments of the Swedish chemist on the juices of all these fruits.

2. Notwithstanding this multiplicity of vegetable matters that contain the malic acid, it is the most abundant, and most pure, in the apple, and this is the fruit from which it is the most easily extracted. The following is the method of proceeding, according to the discovery of Scheele, in the extraction and purification of this acid. Sour apples are pounded in a mortar, the juice is pressed out, it is filtrated through linen, and a solution of acetite of lead, or *saccharum saturni*, is poured into this dissolved salt. The acetous acid unites with the pot-ash, and remains in solution in the liquor, whilst the acid of apples, combined with the oxide of lead, is precipitated in an insoluble malate of lead. This precipitate is then well washed; and treated with sulphuric acid diluted with water, sulphate of lead is formed, which is precipitated, and the supernatant liquor

quor contains the malic acid separate. Care is taken to add a sufficient quantity of sulphuric acid to decompose the whole of the malate of lead; which is known to have been done by the acid, pure taste of the supernatant liquor, free from any admixture of saccharine flavour. Should there be a small excess of sulphuric acid, it is made to disappear by adding a small quantity of malate of lead, which this acid decomposes and converts into sulphate of lead.

3. When the malic acid is found mixed with citric acid, as is the case in many of the juices of fruits, and especially in that of the gooseberry, the following is the method by which Scheele succeeded in obtaining each of these acids separate. He first inspissated this juice to the consistence of honey; he then poured upon it alcohol, which dissolved the two acids, and left a large quantity of gummy mucilage; he afterwards evaporated this alcohol; he diluted the liquor which remained after this evaporation with two parts of water; he saturated it with chalk or carbonate of lime; he separated by evaporation the calcareous citrate which is much less soluble, and the calcareous malate which remained in it afterwards, by a fresh quantity of alcohol, which did not dissolve the salt, but a saponaceous and saccharine matter which was combined with the malate of lime; he decomposed the malate of lime by the acetite of lead; he afterwards treated the malate of lead that was formed with sulphuric acid, and
thus,

thus he obtained the malic acid pure and insulated.

B. Physical Properties.

4. THE malic acid thus prepared is a brownish-red liquid, of a considerably pungent and lively acid taste, without acrimony, but frequently affording a saccharine after-taste, however well it may have been purified. It reddens the blue vegetable colours well.

5. It never assumes the crystalline and solid form ; it becomes thick and viscid like a mucilage or syrup ; when it is exposed to dry air, it dries in minute layers, like a brilliant varnish, and might be employed for spreading over polished surfaces.

C. Chemical Properties.

6. THIS acid is easily decomposed by fire ; it tends to lose carbon speedily ; it becomes of a very deep colour, swells considerably, exhales a thick and pungent smoke in the open air, and leaves a very voluminous coal, similar to those of mucilage and sugar. When it is distilled in a retort, it yields acid water, much carbonic acid gas, some carbonated hydrogen gas, and a light swelled coal. Its empyreumatic acid appears to be the pyromucous acid.

7. It is decomposed gradually and spontaneously in the vessels in which it is contained, it
ferments

ferments sensibly, becoming at first slightly vinous, deposits mucous filamentous flakes, which at last are reduced to coal. It is very evident that this decomposition is produced by the intimate re-action of the component principles of this acid. Its mechanism will be still better understood from the history of some of the subsequent acids.

8. All the powerful acids alter it and change its nature; the concentrated sulphuric acid reduces it to coal; the nitric acid converts it into oxalic acid. Scheele had already found that insipid mucous matter, treated by the nitric acid, passes into the state of malic acid, or was converted at the same time into this acid and into the oxalic. Thus the malic acid is fabricated artificially, and we must recognize in it a double origin, that of nature and that of art, as in several other vegetable acids of which we shall soon treat.

9. The malic acid forms with barites a crystallizable and soluble salt; with lime it yields small irregular crystals, little soluble in boiling water, but very soluble in an excess of malic acid, as well as in vinegar, like the malate of barites itself. The malate of lime thus dissolved by its acid, forms, by thickening in the air, a solid, brilliant substance analogous to a layer of varnish. The malate of magnesia is deliquescent, that of alumine has little solubility. The malates of zircon and of strontian are not known. The malates of pot-ash, of soda, and
of

of ammonia appear to be susceptible of attracting the moisture of the atmosphere. The comparative attractions which this acid exerts upon the different alkaline and earthy bases have not been determined, so that the laws relative to the decomposition of these salts are as yet unknown.

10. The malic acid precipitates the nitrates of mercury, of lead, and of silver, and is thence distinguished from the citric acid, which does not effect this precipitation in like manner. It also decomposes the solution of gold diluted with water, the metal of which it reduces. It dissolves iron, and forms with it a brown uncrystallizable liquid; with zinc, which it dissolves well, it gives a salt in regular crystals of considerable magnitude. Its combinations with other metallic oxides have not yet been studied.

11. It presents itself in all these phenomena of combination and of decomposition, though hitherto little known, as a vegetable acid in which the proportion of carbon is pretty considerable.

D. Uses.

12. THE malic acid has hitherto been prepared only for chemical uses, and for the series of experiments that lead to a knowledge of its properties. It might serve for a refreshing beverage,

beverage, or as a condiment, like several other vegetable acids.

SPECIES V.

The Citric Acid.

A. History, Seat, Extractions.

1. CHEMISTS formerly compared the acid juice of lemons with the acid of tartar: they endeavoured to concentrate this acid and to purify it, in order to prevent this juice from becoming altered and spoiled, as usually happens when it is kept in bottles. In fact, every one knows that this juice, though very acid, and weighing 1060 according to Citizen Guyton, becomes turbid and covered with mould when it is kept in vessels; it deposits mucous flakes, and at last loses its acidity; assuming a very disagreeable, putrid, and faint taste. Some persons have partly defended it against this alteration by covering it with oil in the vessels in which they kept it; others thought to effect this purpose by putting sand into it; and others added to it a mineral acid; but these different means either themselves contribute to alter it, or do not prevent its change. The oil, which was most preferable, did not, however, prevent the lemon-juice from contracting, after

some days, a harsh, oily, and disagreeable taste.

2. Mr. Georgius published, in the Memoirs of Stockholm for 1774, a better process of concentration. This consisted in keeping the lemon-juice for some time in a cellar, in inverted bottles, in order to separate from it a part of the mucilage, and afterwards to expose it to a cold of from 4 to 5 degrees below 0; the aqueous part was thus congealed, taking with it a portion of the mucilage; this was separated, and the liquid was continued to be exposed to the frost, till the concrete portion had an acid taste. The juice thus reduced to one eighth of its original volume, is eight times stronger than before, and it requires the same quantity of pot-ash to saturate it as the original quantity of the juice required. In this state of concentration, it remains unaltered, and may be employed for every domestic and economical purpose.

3. It is well known to every one who has extracted and examined the juice of the lemon, that this liquid, when exposed to the air in an open vessel, at a temperature of above 15 degrees, deposits a mucous, whitish, semi-transparent matter, of a gelatinous consistence. When the juice is decanted from over this deposition, and filtrated, it is much less alterable than it was previous to the operation. The uniform substance thus separated is not a simple vegetable mucilage: I have found that when dried it is not soluble in boiling water; that,

that, if treated by the nitric acid, it yields azotic gas, is converted into malic and oxalic acids, and that it thus has some analogy with the glutinous principle. This explains a process followed and described by Citizen Dubuiffon Limonadier, at Paris, for the purification and preservation of lemon-juice. By evaporating it with a gentle heat, continued for a long time, he found that its mucilage became thickened, and separated in the form of a glutinous crust and flakes; the acid liquor then becomes concentrated and may be kept for a long time in well-corked bottles; there afterwards separate from it only a few white and solid flakes which swim upon the surface, without the nature of the acid being changed, or its flavor being altered, or losing any of its strength.

4. These different means, however, were only in some measure preparatory; they did not yet afford either a method for obtaining the citric acid really insulated and pure, or an opportunity for examining its properties. Scheele nearly accomplished this work by presenting a process for obtaining the citric acid considerably pure; and to him we are at the same time indebted for the first description of the real distinctive characters of this acid, which till this time had been confounded with the tartarous. Stahl indeed knew, at the commencement of the century, that lemon-juice combined with Crabs claws assumed the nature of vinegar; several chemists also had described, after him, some

properties of the combinations of this acid; but these were only vague and inaccurate notions before the discoveries of the Swedish chemist. The following is the method by which he succeeded in obtaining the real citric acid, after having tried in vain to purify the lemon-juice with alcohol, which does not separate the mucilage completely enough to insulate this acid, or to admit its being obtained in crystals, as may be done when it is sufficiently pure.

5. The lemons are pressed, the juice filtrated or drawn off clear is saturated with carbonate of lime. After the effervescence which disengages the carbonic acid, a pulverulent insoluble salt is formed, which precipitates to the bottom of the liquid; the supernatant water retains the mucilage, the extract, and the colouring matter of the juice; the precipitated citrate of lime is washed with lukewarm water, till this passes off colourless; it takes up only about as much salt as it would take of sulphate of lime: the salt washed with a little water is poured into a matrafs; a quantity of concentrated sulphuric acid requisite for saturating the proportion of chalk that has been employed is added, after having diluted this acid with ten parts of water; it is then boiled for a few minutes, and after cooling, the liquor is filtrated: the sulphate formed by the decomposition of the calcareous citrate remains upon the filtre; the liquor that has been filtrated contains
the

the citric acid pure; it is evaporated to the consistence of a clear syrup, and put to crystallize in a cool place: in this manner we obtain the citric acid in small needles. According to Scheele, it is necessary to add a small excess of sulphuric acid, which remains in the mother-water of the crystallized acid. This excess produces better effects than an excess of lime or of citrate of lime, which would prevent the crystallization of the citric acid.

6. I have proposed long since to execute this process in the large way in our American possessions, where lemons are so abundant, and where a large quantity of them is lost; it would only be requisite to saturate the expressed juice with chalk, to wash the precipitated calcareous citrate well till the hot water passes off insipid and colourless, to dry the precipitate well, and to send it, pressed in barrels, to France, where it might be decomposed by means of diluted sulphuric acid, in order to obtain from it the citric acid pure. This process which I have indicated more than ten years ago in my course [of lectures] will be very economical and very useful; it will give a value to immense quantities of lemons that have hitherto been lost, and will furnish a substance which is so often wanted, which is always scarce and dear in the North of Europe, and which is so useful for chemical and medical purposes. Since I have indicated it, I have not had the satisfaction of seeing it put in practice; but this view will not always

be lost, and it is to be believed, that when it shall have been diffused amongst the American colonists, it will present them with the means of turning to profit a product which is so abundant near their habitations, and which they suffer to be lost in such large quantities.

7. Citizen Dizé, an able practitioner of Pharmacy at Paris, by repeating with care and upon a very large scale the process of Scheele for extracting the pure citric acid from the juice of the lemon, in the large pharmaceutical establishment at the military School, of which he has the direction, has had an opportunity of making some important observations on this preparation. He has assured himself, not only that an excess of sulphuric acid is necessary for obtaining this acid pure, but that it serves to destroy the portion of mucilage which alters it, by determining its decomposition; he has observed that, in order to have the citric acid perfectly pure, it was necessary to dissolve and to crystallize it several times successively. He has succeeded in obtaining it in the form of very voluminous, and almost gigantic crystals, perfectly formed, and the figure of which he has been able exactly to determine. He has described its solubility, compared its energy, confirmed the facts announced by Scheele, relative to its action upon the solutions of some earthy and metallic salts, and thus rendered its history more exact.

8. Lastly, Citizen Vauquelin has undertaken, at my solicitation, a series of experiments

ments upon the saline combinations of the citric acid, and has greatly added by his researches to the small stock of knowledge that before existed relative to the properties of this acid; so that it was now one of the best known of all the acids which the vegetables present.

I ought here to repeat that the citric acid is rarely found alone, but mixed with different proportions of malic acid in the juices of the barberry, the cherry, the strawberry, the raspberry, the fruit of the service tree, the elder, and a multitude of other fruits; that it is easily separated from this malic acid on account of the little solubility of the citrate of lime which is precipitated, whilst the malate of the same base remains in solution in the liquor.

B. Physical Properties.

9. THE citric acid, when sufficiently pure, crystallizes in rhomboidal prisms, the sides of which are inclined towards each other at angles of about 60 or 120 degrees, terminated at both ends by summits with four faces, which intercept the solid angles; the beautiful crystals are obtained only by letting large quantities of the solution of the well-purified acid evaporate to the consistence of a clear syrup. The small quantities upon which Scheele operated did not permit him to have it regular, and it is only since the operations in the large way of Citizen Dize

Dizé that the perfect form which I have just described has been known.

10. The citric acid has so strong and pungent a taste in this state of crystallization, that when tasted we experience a sensation almost like that of a caustic; it, however, is not such, and when diluted with a little water, its cool, though pungent taste is agreeable; it is not characterized, or at least but very slightly with the smell of the lemon. It strongly reddens the blue vegetable colours; it melts very quickly in its water of crystallization under the action of the fire.

C. Chemical Properties.

11. WHEN the solid citric acid is heated upon ignited coals, it soon fuses and runs; it swells and exhales an acrid and stimulant vapour, which does not resemble that of fried sugar or caramel, as that of the malic acid does; treated in the same manner it is at last reduced into coal, which is not by far so abundant or so much inflated. Distilled in a retort, it is disengaged in part without decomposition; it appears to yield a portion of vinegar; afterwards it gives carbonic acid gas, a little carbonated hydrogen gas, and a light coal remains in the retort. In general, it is one of the acids that most resist decomposition by fire.

12. When exposed to the air, it seems to effloresce in a dry and warm atmosphere; but it
absorbs

absorbs humidity when the air is charged with it, and at last loses its crystalline form. It is very soluble in water; Citizen Vauquelin has estimated that 100 parts of this acid dissolve in 75 of water at 15 deg.: this solution produces some degrees of cold. Though it is much less alterable than most of the other vegetable solutions, it is nevertheless at last decomposed when kept for a long time in close vessels; it precipitates mucous flakes; it is probable that it is converted into acetous acid previous to its destruction.

13. The citric acid is not altered by any combustible body; charcoal alone amongst these bodies appears to be capable of whitening it. The more powerful acids decompose it with much more difficulty than they do the other vegetable acids. However, the concentrated sulphuric acid manifestly converts it into acetous acid. The nitric acid, according to Scheele, does not change it into oxalic acid; but Citizen Vauquelin and myself have found in our inquiries, that in the course of time, by employing a large quantity of it and heating it for a long time, the citric acid is decomposed by the nitric acid, and converted into a small portion of oxalic acid, and a much larger of acetous acid.

14. The combinations of the citric acid with the earthy and alkaline bases have been examined with considerable care by Citizen Vauquelin.

A. Twelve parts of citric acid dissolved in water yielded twenty-four parts of citrate of barites. The first portions of the solution of barites, poured into that of the citric acid, form a flaky precipitate soluble by agitation; the precipitate was not permanent till the period when the whole of the acid was saturated: this salt, at first deposited in the form of powder, collects itself afterwards into silky tufts, and a kind of silvery bushes, very brilliant and beautiful. A large quantity of water dissolves it. This citrate contains equal parts of acid and of base.

B. Twenty-four parts of citric acid required eighteen parts of crystallized carbonate of lime for their saturation. 100 parts of this salt contain 37,34 of lime and 62,66 of citric acid. When the citric acid had been saturated by the lime, small crystals were formed, which precipitated themselves upon the carbonate of lime, and cover it in such a manner as to oppose its solution, in order to complete which it is necessary to stir it from time to time. This is the salt which is prepared in order to purify and obtain the citric acid: it is known to be very little soluble, and decomposable by the sulphuric acid.

C. Thirty-six parts of acid dissolved in the proportion indicated No. 12, a proportion which has been constantly employed in the experiments of Citizen Vauquelin, required for their saturation 61 parts of crystallized carbonate of pot-ash. Hence it follows that 100 parts of citrate

citrate of pot-ash contain 55,55 of acid, and 45,45 of pot-ash. This salt is very soluble and does not crystallize without difficulty; it is also deliquescent and decomposable by barites and lime.

D. 36 parts of acid solution absorbed 42 parts of dry carbonate of soda; whence it follows that the citrate of soda contains 60,7 of citric acid, and 39,3 of soda. This salt is very soluble; one part requires only $1\frac{2}{3}$ of water to dissolve it. Its taste is saline and faint; it crystallizes in prisms of six sides without pyramids; it slightly effloresces in the air without being reduced into powder. It boils, swells, and is reduced to coal by the fire. Barites, by decomposing it, forms a precipitate. Lime-water, though it decomposes it, does not render its solution turbid, notwithstanding the sparing solubility of the calcareous citrate.

E. 36 parts of acid, dissolved, saturated 48 parts of crystallized carbonate of ammonia. 100 parts of this ammoniacal citrate contain 62 parts of acid and 38 of ammonia; it is very soluble in water; it does not crystallize unless when its solution has been condensed: the form of these crystals is an elongated prism.

F. 36 parts of acid required forty parts of carbonate of magnesia for their saturation. One hundred parts of magnesian citrate contain 33,34 of magnesia, and 66,66 of acid. The condensed solution of this salt did not crystallize, after some days, when, by a slight agitation,

tation, it assumed the form of a single white and opaque mass, which remained soft, separating itself from the sides of the vessel, and contracting its dimensions and elevating itself in the middle, in the form of a mushroom nearly twelve centimetres in height.

G. The citrates of strontian, of glucine, of alumine, and of zircon, have not yet been examined.

15. Hitherto the action of the citric acid upon the metals has been little studied: we have seen that Scheele found that this acid did not precipitate the nitric solutions of the white metals, as the malic acid does. Citizen Vauquelin has studied some of the combinations of the citric acid with those combustible bodies. The following is a sketch of his researches on this subject:

A. Fifty parts of zinc being put into a solution of citric acid, an effervescence was occasioned by the disengagement of hydrogen gas. At the end of twenty-four hours the action was over, and the liquid had deposited upon the sides of the vessel, and at the surface of the plates of zinc, small brilliant crystals insoluble in water. One hundred parts contain nearly equal parts of acid and of oxide of zinc.

B. Iron was attacked in the same manner as zinc by the liquid citric acid; the effervescence continued four days; the solution was of a brown colour; by spontaneous evaporation it deposited small crystals of citrate of iron. By evaporation

it

it became black like ink, ductile like hot resin, pulverulent, and very black when cold. This salt is very astringent and very soluble in water. It contains 30,38 of oxide of iron, and 69,62 of citric acid.

C. The citric acid does not attack silver, but it unites with its oxide, with which it forms a salt insoluble in water, of a harsh and very strong metallic taste, which assumes a black colour when exposed to the rays of the sun, is decomposed and yields acetous acid, if concentrated by distillation, and after this operation, leaves the metallic silver in vegetation, of a very agreeable appearance at the bottom of the retort, mixed with a little coal. This salt is decomposable by the nitric acid; it contains in an hundred parts thirty-six of citric acid and sixty-four of oxide of silver.

D. The citric acid does not unite directly with mercury, but it combines very well with its oxide. Red oxide of mercury placed in contact with a concentrated solution of this acid, produces a lively effervescence, becomes white, and assumes a form of a very solid mass. By adding water to this solid compound, it becomes white like milk; by heating the liquid, a very sensibly acetous smell becomes at last perceptible. This salt is not perceptibly soluble, though it has a mercurial taste. The nitric acid decomposes it. Distilled with a naked fire it yields acetous acid and carbonic acid, without hydrogen gas: the mercury is reduced,

reduced, and there remains a light coal in the retort.

16. By comparing all the properties of these different salts, Citizen Vauquelin has drawn from their properties some important results for the history of this acid, and for the characters of the genus of the citrates. All the alkaline citrates are precipitated by the solution of barites. The precipitate which they form with the calcareous salts is soluble in less than five hundred parts of water. All these citrates are decomposed by the powerful acids, which do not form in them any precipitate as they do in the oxalites and the tartrites. The oxalic and tartarous acids decompose them, and form in their solutions crystallized or insoluble precipitates. All these yield either traces of acetous acid, or a product of this nature by distillation; this character exists particularly in the metallic citrates. The citrates placed upon burning coals are fused, swell, exhale an odour of empyreumatic, or burned acetous acid, and leave a light coal. All, when dissolved in water, and left to themselves for a longer or shorter time, are decomposed, deposit mucous flakes which become black, and leave their bases insulated in combination with carbonic acid, one of the products of this decomposition: before the complete decomposition, they seem to pass into the state of acetites.

17. The attractions of the citric acid for the bases have been ascertained by the same chemist
in

in the following order; barites, lime, pot-ash, soda, strontian, magnesia, ammonia, and alumine; its attractions for zircon, and glucine are not yet known. Neither have its attractions for the metallic oxides been determined, nor in what order each of these burned bodies adhere to this acid.

D. Uses.

18. The citric acid is very much used in the state of lemon-juice. It is a condiment which is preferred to vinegar on account of the slight aroma which accompanies it. When purified it may supply the place of the juice of the fruit in all economical uses; but it should be employed in very small quantities. As it may be kept without alteration in its crystalline form, it would be very advantageous to prepare the citrate of lime in our colonies, and import it into Europe, where its acid might be extracted by means of weak sulphuric acid. Two grammes of this concrete acid, dissolved in a kilogramme of water, with a sufficient quantity of sugar and *oleo-saccharum* made with lemon-peel, afford a very agreeable lemonade.

SECTION III.

Second Genus of the Vegetable Acids, or Acidules.

1. THE term of acidules is applied in the methodical nomenclature to the natural combinations of the acids, with a portion of pot-ash, which remarkably changes their properties.

There are only two of these acids that have hitherto been found in this state of semi-saturation. The other vegetable acids do not affect this state of acidules, as they have not the property of being able thus to unite in part with pot-ash, and to remain in a state of semi-saturation with this species of alkali; the cause of the existence of this property in only two, and its absence in all the others, is yet entirely unknown; it depends, undoubtedly, upon the intimate nature of these bodies, and their order of primitive composition.

2. At the same time that only two acids have hitherto been found to possess the character of acidity, it is to be observed, that these same acids are not found, or are found but very rarely in the pure state, and without being semi-saturated with pot-ash; which is owing, on the one hand, to the great tendency which these acids

acids have to unite with pot-ash, or the very strong attraction for it, which they possess; and on the other, to the circumstance that this species of alkali very frequently exists in the vegetables. However, we should not be too hasty in concluding, from their never yet having been found pure in vegetable substances, that they may not still be found in them in that state. Citizen Deyeux already assures us, that he has observed the not-acidulous oxalic acid issuing from the pores of the fibres of chick-pease, *cicer arietinum*; and this discovery is sufficient to announce, that new researches may hereafter increase our stock of knowledge relative to this subject; but it is no less true, that in the present state of chemistry this circumstance seems to be very rare in comparison with those in which the acidules exist.

3. I have already remarked, that only two species of acidules are hitherto known: the one is termed the oxalic acidule, the other the tartarous acidule; but as each of these acidules requires the examination of its pure acid in particular, I shall treat under each species of two varieties, namely, of the native acidule, and of the acid which is extracted from it.

SPECIES I.

VARIETY I.

*Native Oxalic Acidule.**A. History, Situation, Extraction.*

I. THE name of oxalic acidule is applied to the natural semi-saturated combination of the oxalic acid with pot-ash; it is what was termed, previous to the establishment of the nomenclature, *salt of sorrel*. It has long been known that several species of this genus of plants, and especially that which is termed wild sorrel, *rumex acetosella*, as well as the plant termed alleluia, *oxalis acetosella*, yield by evaporation a concrete acid salt. Duclos is one of the first who has mentioned it in the Memoirs of the Academy, for 1688; Junker has likewise spoken of it; Boerhaave has carefully described, in his Elements of Chemistry, the process for obtaining this salt, which he has compared with tartar. Margraff first discovered the presence of pot-ash in this acid salt, as well as tartar. Since this illustrious author, the labours of chemists upon this salt have been so far multiplied, as to render its history still much more exact than it was at the period when the chemist

chemist of Berlin made his researches. Amongst this class M. M. Savary, Wenzel, Wiegleb, Bergmann and Scheele are particularly to be mentioned.

2. The oxalic acid, or salt of forrel is obtained by expressing the juice of the plants which contain it, the forrel and the alleluia *oxalis* in full vegetation, evaporating it, and letting this inspissated juice cool slowly to the consistence of a thin syrup. By this first operation, it is deposited in small crystals, or crystallized plates of a dirty yellow colour. It is re-dissolved several times in succession, and each time the solution is made to crystallize, till the acidule is white and pure. According to the number of operations to which it is subjected it has different qualities in commerce. Some chemists assert, that argil is employed in order to purify this acidule; but the fact is neither confirmed nor probable. One hundred parts of *oxalis*, in full vegetation, afford, according to Mr. Savary, fifty parts of expressed juice, which afford only a little more than one two-hundredth part of acidule in considerable purity. In commerce we distinguish the salt of forrel of Switzerland, which is the whitest and the purest, and that of the forests of Thuringia which is impure and yellowish. That of Switzerland is prepared from the *rumex acetosella*, or the wood-forrel; that of Thuringia is extracted from the *oxalis oxitriphillum*, or *alleluia*.

3. Baunach has described the process which is practised in Swisserland, and, especially in the Black Forest, for extracting the juice of sorrel from the *rumex acetosa* of Linnæus. This plant is cultivated in abundance in this country; it is cut in June; it is put in a mortar containing about 300 kilogrammes of juice, and it is pounded with a wooden pestle moved by water. The juice and the dregs are put into large tubs where it is suffered to rest, water being first added to it, for several days; the whole is subjected to a press similar to that used for grapes; the marc or dregs is pounded a second time, after a fresh quantity of water has been added to it, and it is expressed a second time. All the juice that has been collected is slightly heated and poured into several vats; water is added, in which fine argil has been mixed, in the quantity of nearly one hundredth part of the juice; the liquor is decanted, and that which contains the marc is filtrated through fine woollen cloth. The juice thus clarified is put into large boilers of tinned copper; it is gently boiled and evaporated till its surface is covered with a pellicle; it is then poured into earthen dishes, which are placed in cool situations, where they are suffered to remain quiet for a month; the liquor is then decanted, and an irregular greyish salt is found upon the sides of the vessels; the liquor is evaporated a second and a third time, and a small quantity of argil is added to it. The last mother water contains

muriate and fulphate of pot-ash ; it is still four, and appears to contain another acid. The salt is purified by dissolving it in a sufficient quantity of water, and causing it to crystallize. According to the experiments of the author, the juice of sorrel yields a little less than $\frac{1}{100}$ of its weight of purified acidule.

4 The oxalic acid may be formed in the direct way, as it was first formed by Scheele, by combining with the artificial oxalic acid already indicated, and which shall soon be described, about one-fourth part of its weight of pot-ash : this is an experiment which is performed with success daily in the laboratories of chemists ; by throwing a little liquid pot-ash into a concentrated solution of oxalic acid, small crystals of acidule are soon precipitated.

B. *Physical Properties.*

5. THE pure oxalic acidule of commerce is in small white needled or lamellated crystals. Capeller and Ledermuller have represented them by the microscope ; nevertheless their form has not yet been very exactly determined. Romé de Lisle has defined them as consisting of very elongated parallelopipedons. When we break them, we perceive in them groups of leaves or plates applied one above the other : it is always of an opaque, and not very brilliant white colour, except in the small fragments which are separated by the fracture.

6. Its

6. Its taste is sour, pungent, and a little acerb; it strongly sets the teeth on edge; it is not mixed with any foreign taste, being neither bitter nor acrid; it is not disagreeable, but on the contrary pleasant and cooling; it strongly reddens blue vegetable colours; it is very brittle; is easily reduced into a very dry powder; it crackles and decrepitates in the fire, but cannot be fused without a more or less considerable alteration in its principles.

C. Chemical Properties.

7. If we expose oxalic acidule upon an ignited coal, it swells but little; it exhales, almost without becoming coloured, a very pungent and very sour smell; it leaves scarcely any coal, and appears to sublime. Before the blow-pipe it quickly disappears, and leaves only a little alkaline ashes, after having been treated in this manner. Four hundred and eighty parts of this acidule were distilled in a glass retort, by a well-regulated fire, by Mr. Wiegleb; they yielded one hundred and fifty parts of a very acid water, without smell and without colour. There remained 160 parts of a grey residuum, from which were extracted 156 of pot-ash; about four parts of a concrete acid were sublimed into the neck of the retort; not a drop of oil passed over. Mr. Wiegleb has made no mention of elastic fluid; but it is easy to
conclude

conclude from the 166 parts of loss, which he had in his operation, that carbonic acid gas and a little water were disengaged, which he did not collect. The acid obtained in this distillation appears to be pure oxalic acid; whence it follows, that the acidule does not undergo any strong alteration by this treatment, and that it is only in part separated from the pot-ash.

8. The oxalic acid does not suffer any alteration by the air; when exposed to it, it remains dry and crystallized, without either its form, consistence, or colour being changed. It is very soluble in water: according to M. Wieg-
leb, one part is dissolved in six parts of boiling water; but he adds, that it is almost entirely precipitated by cooling, notwithstanding the addition of six more parts of cold water. Mr. Wenzel carries its solubility still farther, since, according to him, boiling water takes up more than two-thirds of its weight: cold water, however, takes up or retains about a thirtieth part of it. Boiling water, which dissolves it so much more abundantly, suffers it to separate in crystals, by very slow refrigeration. It is purified and obtained well crystallized by this process.

9. The cold and saturated solution of oxalic acid has a sour, pungent taste that sets the teeth on edge; it reddens the blue vegetable colours. When kept for a long time it crystallizes regularly without being decomposed or its nature
3 changed;

changed ; this preservation, or exemption from spontaneous decomposition, is one of the distinctive characters of this acidule, by which it is most distinguished from the second species, or the tartarous acidule, which, like many vegetable acids, is susceptible of alteration, and entirely loses its acidity. Citizen Berthollet has well described the decomposition of the latter, and the non-decomposition of the oxalic acidule, in a Memoir, the principal results of which I shall present to the reader.

10. The acids decompose, though with difficulty, the oxalic acidule, which is nothing but the acidulous oxalate of pot-ash ; according to Mr. Wiegleb, by heating this acidule with sulphuric acid, the disengagement of its acid is promoted ; the nitric acid also separates it, according to the experiments of Margraff, but in a very different manner than it does the tartarous acid from its acidule ; it was by this process that he proved the presence of pot-ash in both of these acidules. The muriatic acid effects the same decomposition, though with more difficulty, and leaves muriatic acid in the liquor. These decompositions, however, are effected only by the aid of heat ; in the cold none of these acids separates the acid from its acidule ; which is owing to its attraction for the pot-ash.

11. Several earthy and alkaline bases unite with the oxalic acidule without decomposing it, and

and cause it to pass into the state of a triple or triple salt. Such particularly are barites, magnesia, soda, and ammonia. The triple oxalates have not yet been examined with the attention requisite for determining their characteristic properties. Pot-ash forms with it saturated oxalate of pot-ash, which shall be described hereafter. Lime decomposes it by seizing the whole of its acid, both that which is free, and, as it were, insulated, and that which is more engaged in the portion of pot-ash which it contains. Chalk, or carbonate of lime, effects the same decomposition: it has been ascertained that 100 parts decompose 137 parts of oxalic acidule, that 175 parts of precipitated oxalate of lime, are obtained, and that the supernatant liquor yields thirty-two parts of carbonate of pot-ash. This decomposition proves that lime has a stronger attraction for the oxalic acid, and separates it from pot-ash.

12. The oxalic acidule decomposes all the calcareous salts, the sulphate, the nitrate, the muriate, the phosphate, because its acid has a stronger attraction for lime than those acids have; accordingly, it may be generally applied to ascertain the existence of those kind of salts, and even their proportion or their quantity. I shall speak again more fully concerning this important fact, in treating of the pure oxalic acid.

13. The oxalic acidule attacks iron, lead, tin, zinc, and antimony, but does not affect the other metals; it dissolves almost all the
metallic

metallic oxides with which it forms triple salts, almost all crystallizable, and not deliquescent, by combining with them intire and without losing its pot-ash. The properties of these very singular salts have not yet been sufficiently examined. As the same acidule in solution precipitates the nitric solutions of mercury and silver into insoluble metallic oxalates, Bayen, by examining the supernatant liquors of those precipitations, and finding in them nitrate of pot-ash, has confirmed, by this easy and simple operation, the presence of that alkali in the salt of forrel.

14. I have here indicated only the chemical properties that belong to the acidulous oxalate of pot-ash, or the oxalic acidule, such as it is extracted from forrel and some other plants, under the name of salt of forrel: from these I have carefully separated all those that depend solely upon the pure oxalic acid, as I shall show in the history of the latter in particular. According to the analyses that I have quoted, the oxalic acidule contains more than one-third of pot-ash; the rest of its weight is formed of oxalic acid and water.

D. Uses.

15. THE salt of forrel is especially employed for taking out spots of ink from white piece-goods, by reason of the very solvent action which it exerts upon the gallate of iron. It is also

also used in the treatment of diseases in the form of a cooling drink, by triturating it with sugar, and adding to it a few drops of volatile oil of lemons. The experiments of Citizen Berthollet have shown him that the oxalic acidule preserves flesh better from corruption than the tartarous acidule; so that it has appeared to him that the salt of forrel might be employed as an antiseptic with much better success than cream of tartar. In chemistry, the oxalic acidule is treated, in order to ascertain its character or properties, and sometimes to extract the oxalic acid from it, as I shall proceed, to show,

SPECIES I.

VARIETY II.

Oxalic Acid.

A. History, Situation, Extraction.

1. ONE of the most beautiful and most remarkable parts of the history of vegetable chemistry is that which relates to the discovery of the oxalic acid. This acid had long remained, as it were, concealed in the salt of forrel, which had always been confounded, before Bergman and Scheele, with tartar and its acid. When the former of these chemists had discovered, in the year 1776, the conversion of sugar into
a very

a very strong acid by means of nitric acid, Scheele discovered some years after, in 1784, that this artificial acid existed ready formed in the salt of forrel, which contained it intire; that Bergman's acid of fugar might be converted into salt of forrel, by combining a little pot-ash with it, and that we may extract from the native salt of forrel an acid perfectly similar to that which Bergman had prepared from fugar. This is the reason why, on account of this identity, since confirmed by all chemists, this acid has been termed the oxalic in the methodical nomenclature.

2. The following is the process by which Scheele succeeded in extracting from salt of forrel the pure acid which is contained in it, and separating it from the pot-ash. The oxalic acidule of commerce is saturated with ammonia, by which means a triple salt is formed, an oxalate of pot-ash and ammonia, very soluble in water; into the solution is poured nitrate of barites also dissolved; a precipitate of oxalate of barites, insoluble in cold water, is formed, and the supernatant liquor retains nitrate of pot-ash and nitrate of ammonia in solution. We are obliged to proceed in this manner in order to saturate the free portion of the oxalic acidule with ammonia, which would not otherwise decompose the nitrate of barites, because it precipitates it only by double attraction. The precipitated oxalate of barites is then well washed, and decomposed by sulphuric acid which
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has much more attraction for barites than the oxalic acid has; the sulphate of barites which is formed, remains insoluble at the bottom of the liquor: this is decanted; it is tried by a boiling solution of oxalate of barites, in order to separate from it any portion of sulphuric acid that may still exist in it, and when it no longer forms any precipitate by the addition of this solution, the liquid, which then contains the pure oxalic acid, is separated or filtrated: by evaporating this liquid to a proper consistence, it furnishes, on cooling, prismatic or needled crystals of this acid. We may also obtain it by saturating the oxalic acidule with pot-ash or soda; by pouring the solutions of these trifles into a solution of nitrate of barites, and afterwards decomposing the oxalate of barites which is precipitated, by the sulphuric acid.

3. It is sufficiently known from what I have already shown in several of the preceding articles, that we may form oxalic acid in a direct way with gums or sugar, treated with the nitric acid beyond the formation of the mucous and malic acids for the first, and only of the malic acid for the second of these bodies. We shall soon see that a multitude of other vegetable matters, and even of animal substances, are capable of affording, more or less abundantly, the same acid in a very pure state, by the action of the nitric acid. It must here be added, that this artificial fabrication is frequently more economical and
more

more easily practised than the extraction of this acid from the salt of sorrel, because the latter is always very dear in commerce, and in the artificial formation it is only the acid of nitre which is expensive.

4. Citizen Deyeux has found in the fibres of chick-pease, a considerable quantity of oxalic acid. After having cut off these fibres with scissars at different lengths, those which had remained almost entire, soon showed a small drop of liquor at their extremity; those that had been shortened by one half, took a longer time before they exhibited this effect; and lastly, the filaments that had been cut off near their origin, did not present any exudation till after a lapse of 24 hours. When examined with a strong magnifying glass, the divided fibres presented an orifice, the interior part of which was moist, consequently possessing vegetation. These fibres were then ascertained to be secretory organs, in which was formed a liquid which, by its superabundance, produced a small drop at their extremity. In fact, had they been merely excretory canals, the liquor would have appeared sooner at the extremity of the divided vessels. Besides, Citizen Deyeux found it impossible to discover the presence of the same liquid in the parts situated the nearest to the place from whence the hairs took their rise. The author, after having well examined the phenomenon of the production of this humour, has occupied himself with investigating its nature. He first observes, that
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several chemists, and particularly Mr. Proust, had announced that it was acid, and that it burned the shoes of persons who walked over a field of chick-pease. Citizen Deyeux, having agitated intire plants, the fibres of which were provided with small drops of humour in distilled water, found, on examining this water, that it was charged with pure oxalic acid, and not in the acidulated state. This is the first time that this acid has been found pure and insulated in vegetables. There is reason to believe that by multiplying the same observation and the same chemical examination upon plants from which acid humors spontaneously flow, and which are much more numerous than is generally imagined, this acid will be found in greater abundance than has been suspected. It is evident how important it would be to confirm the discovery of Citizen Deyeux by new researches.

B. Physical Properties.

5. THE oxalic acid crystallizes in tetrahedral prisms, the sides of which are alternately broad and narrow, and which are terminated at each extremity by a dihedral summit. When the crystallization is very rapid, we obtain only small needles without any determinate form. Sometimes it presents itself under that of square or slightly rhomboidal plates.

6. It

6. It has an acid and very pungent taste; we should be inclined to think, on tasting it, that it acted as a powerful and caustic acid; nevertheless it produces no such effect upon our organs. It is very agreeable when diluted with water; the teeth are strongly set on edge by its contact, and it softens and even dissolves them, like all the osseous substances, by a contact of some continuance. Accordingly, some modern physicians, amongst those who have begun to apply the lights of chemistry to medicine, and, in particular, Citizen Bonhomme, of Avignon, have thought that the softening of the bones in the diseases of children, characterized by the softness and crookedness of the bones, was owing to oxalic acid formed spontaneously in their stomachs.

7. The acidity of this acid is so powerful, that three decigrammes are sufficient to communicate a very sensible acidity to a kilogramme of water; it also manifestly reddens all the blue vegetable colours: one part of concrete oxalic acid gives to 3600 parts of water the property of reddening paper coloured with the tincture of turnsole.

C. Chemical Properties.

8. THE oxalic acid, exposed to the fire, is in part volatilized in the liquid form, and even in the solid and crystalline form; only a portion
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of it is decomposed at the highest temperature, and this portion passes into carbonic acid and water; only a very small quantity of coal remains in the retort. The residuum is greyish, and contains carbonate of pot-ash with a little charcoal. The following are exactly the phenomena which the crystallized oxalic acid presents when it is heated by degrees. Exposed to a gentle fire it dries, becomes covered with a white crust, and is soon reduced into powder; it loses three-tenths of its weight. Placed upon an ignited coal, it is exhaled in acrid irritating fumes, and leaves only a white alkaline residuum, without coaly matter; distilled in a crucible, with a strong, though moderate fire, it is fused, becomes brown, boils, and yields an acidulous phlegm, is in part sublimed without alteration, and at last affords a little carbonic and carbonated hydrogen gas. By heating it very strongly, we obtain more of the gaseous product, and of acidulous water, with less of concrete acid: the grey mass which remains at the bottom of the retort is a mixture of carbonate of pot-ash and coal; it is very remarkable that this acid affords no oil in its decomposition by fire.

9. The oxalic acid when exposed to moist air, appears to be deliquescent; nevertheless it becomes pulverulent in hot and dry air; it easily dissolves in cold water, which takes up the half of its weight. When crystals of oxalic acid are thrown into cold water, they emit a slight sound,

which announces the separation of their molecules from each other. The specific gravity of this cold solution is greater than that of distilled water by more than one half. By evaporating this liquor none of the acid is raised, even by ebullition. Boiling water dissolves a quantity of it equal to its own weight, half of which is separated from it by cooling: by performing this operation with caution this acid may be obtained well crystallized.

10. The acids with simple radicals, act upon the oxalic acid with greater difficulty than upon the other preceding vegetable acids. The concentrated sulphuric acid turns it brown, and converts it into coal with the aid of heat. The nitric acid decomposes it by ebullition: it has been said to convert it into vinegar; but this is not probable, for this acid, on the contrary, very easily reduces it into water and carbonic acid. This last result is constantly obtained by employing a sufficient quantity of nitric acid, and heating the mixture for a sufficient length of time. Citizen Vauquelin and I have found in our investigations, that 100 parts of oxalic acid contain 77 parts of oxygen, 13 of carbon, and 10 of hydrogen; so that it is one of the most oxygenated acids in existence; and this is the reason why it can only be decomposed totally.

11. The oxalic acid forms with barites a salt of little solubility, which yields irregular crystals, when it is dissolved in water with an

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an excess of oxalic acid. When we wish to dissolve these crystals in boiling water, this fluid takes from them the excess of acid which they contain, and renders them opaque, pulverulent and insoluble. The properties of the oxalate of strontian are not yet known. Citizen Vauquelin has obtained it by pouring oxalate of pot-ash into muriate of strontian. It appears to be insoluble and composed of 0,59 and a half of earth and 0,40 and a half of acid.

12. Saturated with lime, the oxalic acid forms a salt insoluble in water, pulverulent, which is not decomposable by fire, because the attraction of this acid for lime is so strong, that it takes it away from all the other acids. This oxalate of lime turns the syrup of violets green.

13. The oxalic acid easily dissolves alumine. This solution when evaporated yields a yellowish, transparent, sweet mass, a little astringent, deliquescent, and reddening the tincture of turnsole. This salt swells in the fire, loses its acid, and leaves the alumine a little coloured. The powerful acids decompose it.

14. The combinations of the oxalic acid with zircon and glucine have not yet been examined.

15. The oxalic acid may be united with pot-ash in two ways, either in small quantity, or in sufficient abundance to saturate it entirely. In the first case the salt of sorrel, the oxalic acidul, or the acidulous oxalate of pot-ash, is

regenerated. It is in this fact that the brilliant discovery of Scheele consists. On the one hand, he has proved that we can extract from the salt of forrel, by the process which I have described, a pure, crystallizable acid, in every respect similar to that which is fabricated in the direct way with gum or sugar and nitric acid. On the other hand, he has confirmed his discovery by showing that the acid artificially formed, when united with a little pot-ash, again produces real salt of forrel; and in fact, if we only pour a little solution of pot-ash into a solution of pure oxalic acid, we see a very speedy deposition of small crystals, little soluble, namely, of oxalic acidule or salt of forrel. But in the second case; that is to say, when we saturate the oxalic acid with pot-ash, we have a salt very soluble, difficult to be crystallized, assuming the gelatinous form, which crystallizes in hexahedral prisms with dihedral summits when an excess of pot-ash is added to the liquor. This oxalate of pot-ash is decomposable by fire, and by the mineral acids, which speedily precipitate its solution into acidule; it is capable of forming again the salt of forrel or acidule by an excess of oxalic acid. It is also decomposable by barites and by lime, which precipitate from its solution, insoluble oxalates of these two bases.

16. The oxalic acid is also capable of forming a species of acidule when combined with a small quantity of soda; but when saturated with

with it, it constitutes an oxalate of soda very difficult to be obtained crystallized, more soluble, however, in hot than in cold water, turning the syrup of violets green, and which comports itself in many respects like the oxalate of potash, with the acids, with simple radicals, with its own acid, with lime and with barites. Potash decomposes this oxalate of soda.

17. Combined with ammonia in small quantity, the oxalic acid equally forms a species of acidulous oxalate, little soluble, and crystallizable of which we may, like the two preceding acidules of potash and of soda, saturate the exceeding portion of acid with other bases, and consequently form a kind of triple salts. It was by the same order of complicated attractions, that Scheele by saturating the salt of sorrel, or the native oxalate of potash, with ammonia, formed a triple salt, which he afterwards decomposed by the nitrate of barites, in order to obtain, the pure oxalic acid. But if we entirely saturate the oxalic acid with ammonia, a neutral ammoniacal oxalate is obtained, which yields by evaporation beautiful crystals in tetrahedral prisms terminated by dihedral summits, one of the sides of which, being much broader than the other, intercepts three sides of the prism. This salt is decomposable by fire, which disengages the carbonate of ammonia, and leaves only some slight traces of coal; and also by barites, lime and strontian, which separate the ammonia in the state of gas, and precipitate its solution into insoluble

insoluble earthy oxalates; and by magnesia, which unites with a part into a triple salt; and by the two fixed alkalis which form soluble oxalates. The oxalic acid precipitates it into crystals of ammoniacal acidulous oxalate; the powerful acids with simpler unknown radicals seize the ammonia; the oxalates of pot-ash and soda unite with it into triple salts. It precipitates all the calcareous salts, and it is one of the best re-agents that can be employed for ascertaining in any liquids the nature and the proportion of these salts.

18. We must add to these details relative to the earthy and alkaline oxalates, that all such of these salts as have considerable solubility in water, the latter more especially, which appear to be very decomposable, do not undergo any spontaneous alteration in their solution; that they may be used with advantage, under this relation, not only for determining the presence and the quantity of these salts, but also for decomposing the acidulous phosphate of lime; and that in order to obtain from this all the quantity of phosphate which it contains, the ammoniacal oxalate must especially be employed, as its oxalic acid, by separating all the lime, with which it is precipitated into an insoluble calcareous oxalite, leaves in the supernatant liquor ammoniacal phosphate, which as is well known is very decomposable by charcoal.

19. According to Bergman, the attractions of the oxalic acid for the earthy and alkaline bases are

are to be disposed in the following order: lime, barites, magnesia, pot-ash, soda, ammonia, and alumine. Those of zircon, strontian, and glucine have not been ascertained.

20. The oxalic acid decomposes in part all the salts that have pot-ash for their base, and forms in their solutions oxalic acidule, which is precipitated in small crystals. By continuing to pour oxalic acid into these solutions, after having decanted them from each crystalline precipitation, we at last entirely decompose these salts, so great is the tendency which this acid has to take away pot-ash from the other bases. The same result is not so easily obtained with the salts of soda and ammonia, though they also experience a decomposition, and yield part of their bases to this acid. It decomposes all the carbonates, and expels the acid from them with effervescence.

21. The oxalic acid acts upon several metallic substances, especially those that are capable of decomposing water; it unites more or less easily with all the oxides of the metals; it even takes away several of them from the most powerful acids. Excepting tungsten, molybdena, chromium, uranium, titanium, and tellurium, which have not yet been combined with the oxalic acid, some properties of all the other combinations of this acid with the metals have already been indicated. The following is the summary result of the knowledge acquired upon this subject.

A. With

A. With the oxide of arsenic it forms small prismatic crystals, very fusible, very volatile, and decomposable by heat.

B. With the oxide of cobalt, a pulverulent salt, of a light rose colour, little soluble.

C. With the oxide of bismuth, a white salt in powder, very soluble in water.

D. With the oxide of nickel, a salt of a white or greenish yellow colour, very little soluble.

E. With the oxide of manganese, a salt in a white powder, which blackens by the action of the fire.

F. With the oxide of antimony, a salt in crystalline transparent grains.

G. It acts upon metallic zinc with effervescence, and disengagement of hydrogen gas; the water is decomposed, and the oxidated zinc combines proportionally with the acid. This oxalate of zinc is in a white powder, and of an acerb taste, though very little soluble.

H. It does not act upon metallic mercury; but it easily unites with its oxide, which it whitens by its contact. The oxalate of mercury is in a white powder, which quickly turns black when exposed to the light. The oxalic acid precipitates the nitrate of mercury in a white powder; this precipitate, when heated, fulminates sensibly, according to the remark of Mr. Paken.

I. Poured upon tin, in plates or in filings, the oxalic acid first blackens it, and afterwards covers it with a white powder. The oxalate
of

of tin, which is considerably soluble, has an austere and metallic taste. When its solution is slowly evaporated, it yields crystals in the form of needles or prisms, sufficiently well pronounced. When evaporated more violently, it affords a transparent mass resembling horn.

K. The oxalic acid quickly tarnishes the brilliant colour of lead; it corrodes it; and dissolves its oxide very well. When saturated with it, its condensed solution deposits small brilliant crystals, which quickly become opaque by exposure to the atmosphere. The same acid decomposes and precipitates the nitric solution of lead; if it be poured into this solution a little diluted, it affords crystals in the same manner as is done by the immediate union of the oxide of lead. They are also obtained by adding this acid to the solution of acetate of lead.

L. This acid strongly attacks iron-filings; much hydrogen gas is disengaged from the solution: in proportion as the decomposed water furnishes oxygen to the iron, this metal unites with the oxalic acid, and forms a solution which quickly becomes reddish, when heated or exposed to the air. The oxalic solution of iron is very styptic; it yields by evaporation prismatic crystals of a greenish yellow colour. The same acid precipitates the super-oxygenated salts of iron, and especially the red sulphate of this metal, into an oxalate of a fine red colour, which some chemists have proposed to

to be used in painting. There is no acid which dissolves more quickly and more completely the black oxide of iron when in a state of great division, and especially the gallate of iron. It is, therefore, employed with great advantage for taking out ink-spots, as well as its acidule, or the salt of forrel.

M. The oxalic acid also acts easily upon copper, and produces its green oxidation. It entirely dissolves its different oxides. The oxalate of copper is of a light blue colour, little soluble. The same acid decomposes and precipitates the sulphate, the nitrate, the muriate, and the acetate of copper: the precipitate is a powder of a blueish-grey colour.

N. It does not attack metallic silver; but it dissolves, though in small quantity, the oxide of this metal precipitated from the nitric acid by pot-ash. When oxalic acid is poured into the nitric solution of silver, we immediately obtain a white, thick, insoluble precipitate of oxalate of silver. We obtain the same precipitate with any of the soluble oxalates united with the same solution of silver. This salt is very alterable by the action of light; by exposing it to the rays of the sun, it very quickly turns black. The oxalite of silver formed by this precipitation, when exposed upon coals in a spoon, is dispersed with a noise, and undergoes a kind of fulmination, according to the experiments of Mr. Packen, confirmed by Citizen Guyton.

O. The

O. The oxalic acid exerts no action upon gold, and it exerts very little even upon the oxide of this metal.

P. It dissolves the precipitate of platina, formed by soda; without affecting the pure metal. The solution of oxalate of platina is yellowish, and affords crystals of the same colour.

22. It is to be remarked, that all the combinations of the oxalic acid with the metallic oxides that have been described by Bergman, from whom I have extracted the facts which I have presented to the reader, after having verified most of them, and added to them several phenomena since discovered, are very easy to be decomposed by the fire; that none of them affords even a trace of acetous acid in distillation, whilst all those of the citrates furnish it constantly, and some of the latter frequently afford it in sufficient quantity to enable us to subject it to experiments, and ascertain its nature.

23. All the phenomena which the chemical properties of the oxalic acid present, prove, that this acid is more highly oxygenated than those of which we have hitherto treated; that it is on this account that it cannot form other acids, or pass into another acidified nature; that it is the last term of the vegetable acidification, and that it is no longer susceptible, by any other oxygenated substance, or decomposing process, to be decomposed otherwise

wise

wife than entirely, and so as to produce carbonic acid and water; that it contains, as we have seen, a small quantity of carbon; that it is on this account that it yields no oil in distillation, and leaves no coal. Accordingly when this acid is formed in the direct way, with sweet, insipid, saccharine and vegetable substances, and nitric acid, we diminish their proportion of hydrogen and carbon, and augment their proportion of oxygen; so that if this action were pushed a little farther, it would entirely destroy the vegetable composition, and reduce it to the last term of its analysis, by reducing it to the state of water and carbonic acid.

D. Uses,

24. THE pure oxalic acid is not yet employed either in the arts, in medicine, or for domestic uses. It is, as we have already seen, its acidule, which is employed either for making dry lemonade, and for taking out spots of ink. As yet the pure oxalic acid is prepared and employed only in the operations of chemistry. It is particularly used in order to ascertain the presence and the quantity of the calcareous salts. For this purpose, either the acid alone, or the oxalites are used, especially that of ammonia, which is one of the most sensible and useful. It may be substituted instead of the acidule for taking out ink-spots. It may also be prepared as a drink, by diluting

ing it with a sufficient quantity of water, and sweetening it with sugar or honey. It may become very useful, if it should hereafter be found pure, as it probably may, in the juices of acid vegetables.

SPECIES II.

VARIETY I.

Tartarous Acidule.

A. History, Situation, Extraction, Purification.

1. THE tartarous acidule, or the acidulous tartrate of pot-ash, a denomination which exactly designates its nature, has long been known by the name of tartar. It is twenty years since its nature has been well determined. After Paracelsus and Van Helmont, who had erroneous ideas respecting its nature, the labours of a great number of chemists were requisite to bring the knowledge of it to the degree of precision which it has now attained, and to afford precise notions respecting its composition. Fizes, Montet, and Citizen Desmarets have described the processes by which it is purified. Boerhaave, Neumann, Rouelle the younger, Spielman, Corvinus, Bucquet, have proved that it exists ready formed in the juice of the grape, before its conversion into wine. Beguin, Angelus

Angelus Sala, Libavius, Zwelfer, Lefevre, Glazer, and Hierne maintained against many other chemists that tartar contained alkali ready formed. Duhamel and Groffe, Margraff, and Rouelle the younger confirmed this assertion by very exact experiments. Messrs. Wiegleb, Rozensteil, Packen, Bayen and Berniard gave or accumulated by different methods the proofs of the pre-existence of the alkali in this acidule before the action of the fire. After Blaise de Vigenère, Lemery and Neumann, Spielman and Citizen Berthollet have well described the decomposition of this acid by the fire; Corvinus, Citizens Machy and Berthollet, its spontaneous decomposition in water; Scheele, Retzius, Bergman and Packen have given the means of extracting the pure acid from this acidule. Mr. Hermstaedt has carefully examined several properties of this acid. Such is the summary result of the principal investigations that have been bestowed upon the tartarous acid.

2. Though the tartarous acid exists in the juice of the grape, in the tamarind, in fumac, in the tamarisc, in balm, in the carduus benedictus, in the roots of rest-harrow, of germander, of sage, in the fruit of the barberry, and undoubtedly in a multitude of other fruits; it is not from these substances that it is extracted. It is more especially precipitated and deposited from wine kept in casks, and particularly from the wines of France, and those of the Moselle and the Rhine. It forms successive layers which become
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condensed almost like stony incrustations, and which are collected upon the sides of the barrels or casks in which these liquors are kept. The white and red are distinguished by the name of the *white* and the *red* tartar: but it is very far from being pure any more than the lees which contain a very large quantity of it. In tartar and in the lees, besides the colouring matter which they contain, we also find foreign substances, kernels, skins, &c. We likewise find in them sulphate of pot-ash, &c. It is purified in order to separate these foreign matters, by the following processes, described by Fizes, Montet, and Citizen Desmarets.

3. This acidule is in some measure refined or purified in the vicinity of Montpellier, in the manner in which in general many other saline substances are treated. The crude tartar is boiled in water; this boiling solution is filtrated; as it cools it becomes turbid, and deposits irregular crystals in the form of a paste. This paste is boiled a second time in copper vessels, with water in which a fat earth dug at the village of Merviel, near Montpellier, has been diffused. The scum which rises is carefully removed; afterwards a saline pellicle is formed, upon the appearance of which the application of the fire is discontinued; this pellicle is broken, and it precipitates itself with the crystals that have already been deposited: these crystals are washed in water, in order to free them from the earth which soils them. They are introduced into

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commerce under the very improper appellations of *cream* or *crystals of tartar*. The cream has been so called because it is the part formed at the surface; the crystals or the salt of tartar are those which are found beneath. It has been said that the clay serves to free the tartar from the oily matter which was admitted to exist in it; but it is evident that it serves to separate the colouring and extractive part, to which alumine, as we shall see hereafter, has a strong attraction: accordingly this earth answers the same purpose here as in the purification of the salt of sorrel; it discolours and clears the tartarous acidule by favouring its separation, by even taking away its colouring matter.

4. At Venice, a somewhat different method is employed for purifying the tartar. According to Citizen Desmarets, this acidule is dissolved in the state of powder, in boiling water; the foreign or impure substances which it contains are left to subside, and the portion which floats above is taken off. The liquor yields crystals by rest and cooling. These crystals are again dissolved in water which is slowly heated; when this second solution boils, whites of eggs beat up in water and wood-ashes passed through a sieve are thrown in; this addition of ashes is performed fourteen or fifteen times; the scum produced by the effervescence is removed, and the liquor is then left to rest. A pellicle of very white saline crystals is soon formed upon it, the water is decanted and the salt dried. It is

very evident that this process changes the nature of a part of the tartar or of the tartarous acidule, that the pot-ash of the ashes saturates a portion of its insolated acid, as appears from the effervescence which takes place; that part is converted into the state of soluble tartar, and that much of it must be lost by this process. The mother water must contain tartrite of pot-ash or *vegetable salt*, as it was formerly termed. It is equally evident that the Montpellier process deserves the preference.

5. Sometimes the tartarous acidule or the cream of tartar of commerce is purified in laboratories for chemical or pharmaceutical uses. For this purpose it is boiled in water; the boiling solution is filtrated; it is left to cool slowly in vessels of glass, earthen-ware or porcelain; and in this last purification the acidule is precipitated very white, crystalline, transparent, and extremely pure. This is the manner in which it ought to be prepared for medicinal use and for the accurate investigations of chemistry.

B. Physical Properties.

6. THE tartarous acidule when sufficiently pure is in small crystalline fragments, the form of which is difficult to be determined with exactness. However, when we carefully observe the purification of this acidule, we distinguish needles, or quadrilateral prisms, truncated in a sloping

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direction at their extremity. These prisms grouped together produce the irregular masses which form the common cream of tartar.

7. The taste of this acidule is sour, a little disagreeable and not vinous like that of the crude or raw tartar; such as it is taken out of the casks. Its taste is not nearly so acid as that of the oxalic acidule, and it does not set the teeth on edge as that does: accordingly it is not in general so antiseptic as the latter, neither does it preserve food equally well.

8. The tartarous acid is very brittle and pulverizable. As soon as it is heated to softness and incipient fusion, it changes its nature and is decomposed as we shall soon see; it reddens the tincture of turnsole and the syrup of violets.

C. Chemical Properties.

9. WHEN the tartarous acidule is exposed upon a burning coal, it becomes soft, fused, inflated, brown, emits sour, pungent, empyreumatic fumes, of a particular and well determined smell: it leaves a voluminous, abundant, heavy, and very alkaline coal. The decomposition of the tartarous acidule by distillation in a retort is one of the operations with which chemists have been most occupied, and upon the products of which they have amply written. This distillation is performed in a retort of stone-ware or cast iron, to which are fitted an

adopter

adopter and receiver, provided with tubes proper for conducting and collecting the elastic fluids; the fire is applied by degrees and with precaution, and at last pushed so far as to render the bottom of the retort perfectly red-hot. There first passes over water little coloured, and scarcely acid, afterwards a liquid acid stronger and reddish; then an oil which assumes colour and consistence in proportion as the heat is increased, a large quantity of carbonic acid and carbonated hydrogen gas; and at last carbonate of ammonia which crystallizes in the adopter.

Amongst all these products, each of which deserves to be examined in particular, that which has most struck the attention of chemists is the enormous quantity of elastic fluid, which they long conceived to be air. A cubic inch, or 543 grains of tartar of Rhenish wine, gave Hales 304 inches, or 144 grains, or nearly one third of its weight of elastic fluid. Citizen Berthollet computes the quantity of gas extricated by distillation at nearly three quarters of the weight of the tartar. Spielman and Corvinus have calculated that this gas occupies two hundred and forty-four times the volume of the matter employed. Nearly three-fourths of this gas are carbonic acid, and one fourth carbonated hydrogen gas, which burns white or blue, and is mixed in two or three varieties, according to the quantity of carbon, or of intire oil, dissolved in this gas.

The oil which forms, according to Lemery and Spielman, about one sixth of the weight of the tartar, is one of the products of this distillation which differs the most from those of the preceding acidule; it manifestly proceeds from the much larger proportion of carbon and hydrogen contained in the tartarous acid than in the oxalic. It was formerly rectified for the purpose of preparing a strengthening external remedy, which was in high esteem. It is evident that it did not exist ready formed in the tartar, but that it results from the particular union of a certain quantity of hydrogen and carbon; accordingly, it varies as well that as of the acid phlegm and the gases, according to the manner in which this distillation is conducted, and the rapidity and force of the fire that is applied.

Ammonia in the state of concrete carbonate, indicated amongst the products of this operation by Lemery, Juncker, Wiegleb, and especially Bucquet, announces that the tartarous acidule contains azote amongst its primitive principles. A portion, according to those authors, is combined with the liquid acid, of which I shall soon speak: but I must here observe that some modern chemists do not reckon ammonia amongst the number of the products of the decomposition of the tartarous acidule, and think that he was deceived by a small quantity of pot-ash, elevated at the same time

as the liquids and the gases that are disengaged. This fact, therefore, deserves to be verified by new experiments more exact than those that have hitherto been made; for it may lead us to determine whether it be not at the expense of the pot-ash, as was formerly thought, that this volatile alkali is formed, and whether this fixed alkali does not furnish azote which unites with the hydrogen of the decomposed acid.

10. After this decomposition, there remains in the retort a very alkaline and very acrid coal, which attracts the moisture of the atmosphere, which yields much carbonate of pot-ash by mere lixiviation and cold water, and the nature of which serves to prove the presence of this alkali in the proportion of one third of the weight of the tartar in the acidule; for at present it is no longer believed that the pot-ash is formed by the action of the fire at the expense of the total decomposition of the tartarous acid; for this, when pure, as we shall soon see, does not afford the alkali in its coal. Chemists avail themselves of this property of the coal of tartar, in order to extract from it quickly and by an easy process, a considerable quantity of sufficiently pure pot-ash. Crude tartar is put, in the state of a coarse powder, into wrappers of thick brown paper, which are immersed in water; these are placed upon a bed of charcoal in a furnace, which is thus successively filled with alternate layers of papers of tartar and coal, care being taken to cover the last layer

layer with a somewhat thicker stratum of coal. This coal is set on fire, and suffered to become totally extinguished after its complete combustion : when the whole has cooled, the papers are taken out much diminished in volume, as is natural to suppose, but retaining their form, on account of the solidity of the paper and of the water which has agglutinated, and, as it were, united the leaves. These papers contain the pot-ash of the tartar, the coal of which is destroyed ; it is combined with a portion of carbonic acid. Excepting a small quantity of lime and sulphate of pot-ash, which are frequently found in this alkali, it possesses a considerable degree of purity. Formerly it was much employed by chemists, under the name of *fixed salt of tartar*, or *alkali of tartar*. As it contains much pot-ash in an insulated state, it quickly attracts the moisture of the atmosphere, and then forms a thick liquid which was termed *alkali of tartar per deliquium*, oil of tartar *per deliquium* ; this last ridiculous denomination has long been laid aside. Three eighths of the tartar are obtained in this alkali,

11. One of the most remarkable products of this decomposition of the tartarous acidule by fire, is the particular acid which passes in the liquid form in distillation, and which is a new production of the mutual re-action of the principles of the acid, effected by the action of caloric ; this is the *pyrotartarous acid*. I shall speak of it in detail, in treating of the tartarous

ous acid, which likewise affords it by distillation; it is sufficient here to know that it is a modified acid, different from that which existed in the acidule, and which, compared with the other products of this igneous decomposition, shows the great diversity between this acidule and the oxalic acidule. Hence it may be concluded, that this decomposition, which indicates a great abundance of carbon and hydrogen in the tartarous acidule, authorizes the termination in *ous*, adopted by the methodical nomenclature, and opposed to that of oxalic acidule; as this last, not being equally decomposable is much more oxygenated.

12. The tartarous acidule experiences no alteration by the contact of the air; no simple combustible body, if we except carbon, which purifies or whitens it, exerts any action upon it. It is very difficult of solution in cold water, which scarcely takes up more than one sixtieth part of its weight. Boiling water dissolves nearly one thirtieth, the greater part of which is precipitated, and crystallizes by the cooling of the liquor. This solution, which is fourth, and of a disagreeable taste, reddens the blue vegetable colours. When left to itself in a close vessel, it is decomposed, and presents phenomena very different from those which I have described with respect to the oxalic acidule, which does not undergo the same decomposition. Citizen Machy is the first who has spoken of this decomposition, by which he
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wished to prove that the alkali was the product of an alteration, and that it was not contained ready formed in the tartarous acidule; but he was mistaken when he asserted that the mucus that was precipitated did not contain alkali, and that the supernatant liquor was acid, since he has not pursued this decomposition far enough, nor examined the supernatant liquor, which after this decomposition contains the whole of the pot-ash pre-existing in the acidule. Spielman and Corvinus have committed the same error, though they had made a more exact experiment. This spontaneous decomposition has since been followed and described with the most care and success by Citizen Berthollet; he has given the result in a *Memoir* inserted amongst those of the Academy of Sciences, for 1782. After having dissolved one part of tartarous acidule in sixty-four parts of distilled water, he left this solution in a glass vessel covered only with paper, in the natural temperature of his laboratory. The liquor gradually diminished in volume; mucous flakes were precipitated in it, which he did not take away, like Spielman, in order that nothing might be lost. At the end of five months this mucosity was very abundant; the liquor was red, but it still reddened the syrup of violets, and had a sour taste; the mucosity still augmented; he replaced the water which was evaporated, and after eight or nine months the liquor began to turn the syrup of violets green, assuming a more and more deep colour. After this

this spontaneous process had been carried on for eighteen months, the liquor not appearing to him to undergo any more alterations, he filtered it; the mucilage received upon the filtre dried there, losing much of its volume, and being reduced to a very small weight. After having burned it, its ashes yielded only signs of alkalinity; but the supernatant liquid which was strongly alkaline, afforded by evaporation carbonate of pot-ash rather oily, and this being reduced to coal by the action of the fire, weighed five-eighths of the tartarous acidule originally employed; as did the alkali which he obtained by treating a like dose of this acidule by distillation. According to the chemist whom I quote, the tartarous acid decomposed spontaneously, and very slowly by this experiment, formed the mucous flakes that were precipitated, with the carbonic acid, and the small portion of oil united with the pot-ash that remained in the liquor, and existed ready formed in the acidule. I shall subjoin to this detail the result of another experiment adapted to confirm this theory, and leave no doubt of its accuracy; namely, that the pure tartarous acid, which is equally alterable by a slow and spontaneous decomposition, leaves no pot-ash in the liquor which is the residuum of its decomposition, and that the solutions of the alkaline tartrites, in which we know exactly the proportions of alkalis that have been employed for preparing them, leave only these alkalis together

together with the carbonic acid and the small quantity of oil, produced by the decomposition of the acid.

13. The tartarous acidule, which I may equally term *acidulous tartrite of pot-ash*, as the facts that have already been quoted respecting its properties, prove that it is in fact only tartrite of pot-ash with excess of acid, experiences no alteration from any of the acids, unless they have sufficient power to alter the peculiar nature of its acid. The portion of pot-ash which it contains has more attraction for its excess of tartarous acid than any of the acids, even the strongest have; and on this account the tartarous acid decomposes all the alkaline salts till it becomes tartarous acidule. Accordingly, when in the experiments of Pott, of Margraff, and of Rouelle the younger, we find these able chemists succeed in extracting the pot-ash from the tartar, or cream of tartar, by means of the acids termed *mineral*; we are to understand that they succeeded only by decomposing the tartarous acid itself, and converting it either into acetous or oxalic acid. Thus by throwing one part of concentrated sulphuric acid upon one part of tartarous acidule in the state of powder, and favouring the action of this mixture, which becomes much heated at the moment when it is made, with the heat of a *balneum marie*, continued for ten or twelve hours: the two substances form a brown magma. By afterwards pouring into them
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three or four times their weight of boiling distilled water, saturating the sulphuric acid by means of chalk, filtrating and evaporating the liquor, we obtain sulphate of pot-ash mixed with a little sulphate of lime. But what neither Rouelle nor Bernard have announced is, that acetic acid is formed in this experiment. The same circumstance takes place by the muriatic acid. The nitric acid seizes the pot-ash of the tartarous acidule only by causing its acid to pass into the state of oxalic acid.

14. The boracic acid unites without decomposition with the tartarous acidule : one part of the first to four of the second is sufficient to render it soluble in six or eight times its weight of hot water, as Laffone has shown in the Memoirs of the Academy for 1755. It is in this manner that we ought to prepare what has been termed in pharmacy *soluble cream of tartar*, and not with borax ; for this last, which contains much soda in excess, as I shall show on another occasion, constitutes with the tartarous acidule a triple salt, a tartrate of pot-ash and soda, mixed with boracic acid, which is very far from being *cream of tartar*. Accordingly, this addition of borax to cream of tartar for the purpose of rendering it soluble, announced by Lemery, in 1728, in the Memoirs of the Academy ; and proposed in the same year, as a remedy, by Lefebvre, physician at Uzès, in the same academical collection, cannot fulfil the intentions

tentions of the physician, like that of the boracic acid alone.

15. Long ago several of the earthy and alkaline bases have been combined with the tartarous acidule, in order more especially to prepare from it different kinds of medicines. Chemists have examined several of these combinations for better ascertaining the nature and the properties of the tartarous acid; and their labours, as we shall soon see, have reciprocally enlightened the art of healing in the prescription of these medicinal preparations: at least, it is from the pharmaceutical source of these saline combinations, which are almost always triple, that the discoveries which have fixed their nature and properties, have been derived. We must therefore accurately describe these combinations, considering them under the double point of view that has been indicated.

16. The solution of barites decomposes that of the tartarous acidule, seizes its acid, with which it forms an insoluble salt, which is precipitated in a white powder, and leaves the insulated and pure part in the supernatant liquor: it is, as we see, a good mean of proving the presence of pot-ash in the tartarous acidule, and even of determining its proportion. The same is probably the case with strontian.

17. Lime effects the same decomposition, and even in a still more energetic manner, since, according to the order of elective attractions indicated by Bergman, it is more attracted by
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the tartarous acid than barites is. It is to be observed, that I do not intend here to describe the properties of the earthy and alkaline tartrites, which are to be placed in the history of the pure tartarous acid; but that I only consider the action of these bases, as decomposing the tartarous acid, and uniting with it into triple salts. When lime-water is poured into a solution of tartarous acidule, an abundant and pulverulent precipitate of tartrate of lime is produced, and pure pot-ash remains in the liquor. If we take carbonate of lime, as Rouelle has done, this earthy salt acts only upon the free portion of the tartarous acid, with which it also forms insoluble calcareous tartrate in proportion as carbonic acid is disengaged. After this, the supernatant liquor contains the portion of pure and neutral tartrate of pot-ash, with which the tartarous acid was united in the acidule. This is another of those simple and ingenious experiments by which Rouelle the younger proved in an immediate manner the presence of pot-ash in tartar. He thus separated from it the neutral salt which was termed at that time *vegetable salt*, and of which I shall speak in detail in the article concerning the tartarous acid.

18. Magnesia does not act in the same manner upon the tartarous acidule. Though Bergman places it before the fixed alkalis, in his order of attractions for the tartarous acid, it does not appear to be capable of separating the
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pot-ash from this acidule, but rather of remaining united with the acid at the same time with it, and of forming a kind of triple salt. The Chemists of the Academy of Dijon have obtained from the acidulous tartrate of pot-ash, saturated with magnesia, a soluble salt, which yielded them, by its spontaneous evaporation, small aculeated crystals, disposed in rays. Poulletier de la Salle has obtained from the same combination a gelatinous mass, resembling a mucilage.

19. It appears that alumine produces a nearly similar effect with the tartarous acidule, though it unites with it with more difficulty, since, as we have seen above, argil is employed to purify tartar in the vicinity of Montpellier. The action of zircon and glucine upon this acidule is absolutely unknown. Silix does not seem to exert any upon this saline compound.

20. When we combine pot-ash or the carbonate of pot-ash with the tartarous acidule, it becomes saturated entirely with this alkali, and forms the same salt as that which shall be described by the name of tartrate of pot-ash, in the history of the tartarous acid.

21. The same is not the case with soda as with pot-ash: this alkali, by combining with the tartarous acidule which it saturates completely, forms with it a kind of triple salt, which has long been named *Salt of Seignette*, from the name of a pharmaceutical practitioner of Rochelle, who first discovered, prepared, and

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proposed it for medicinal use. As a *trisule*, namely, *tartrite of pot-ash and soda*, the history of this salt must here be explained.

In order to prepare this salt, one part of sufficiently pure tartarous acidule is thrown into five parts of boiling water, and to these is added carbonate of soda crystallized and reduced to powder, till no more effervescence takes place, and till the acidule is completely saturated. In proportion as this saturation is effected, the acidule disappears and dissolves in the liquor; after having drawn it off clear, this is evaporated to the consistence of a thin syrup, and suffered to cool gradually: by this gradual cooling it furnishes large and very regular crystals, in prisms of eight sides nearly equal, which are frequently excavated, as it were, in their middle and almost in their axis; they then resemble a tomb. The broad face upon which they rest then presents two diagonal lines which cross each other at the centre. This salt, which at first was sold as an arcanum, was discovered in 1731, by Boulduc and Geoffroy, who described its preparation in the sittings of the Academy of Sciences of Paris. Since this period all druggists have prepared it in their laboratories; it has become much more common and consequently much better known.

When this salt is prepared, as well as the tartrite of pot-ash or vegetable salt, there remains at the bottom of the liquor a kind of earthy residuum, in the form of clay or paste, some-

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times in that of small needles interwoven with each other. The practitioners of pharmacy, who all know this deposition, had considered it as a species of earth engaged in the *cream of tartar* of commerce, and separated by the soda. Citizen Vauquelin has examined it with care; he has found that it forms about 0,07 of the tartarous acidule, that it is not separated from the pure tartarous acid, that it existed only in the *cream of tartar*, and that it is tartrite of lime afforded by the wine; as he has also found it in crude tartar. He has shown by the same investigation, that the salt of Seignette contains very nearly 0,54 of tartrite of pot-ash, and 0,46 of tartrite of soda; that thus it is accurately termed *tartrite of pot-ash and of soda*. This triple salt has a bitter taste; it is decomposed by the fire, and yields pyrotartarous acid, oil, and gas, like all the tartrites; it effloresces in the air; it is soluble in about five parts of water; it is decomposable in part by the powerful acids which precipitate from it the tartarous acidule; it is entirely decomposable by barites and by lime.

22. The tartarous acidule combines also with ammonia, which saturates it into a triple salt. This tartrite of pot-ash and of ammonia affords fine crystals, which Bucquet has described as pyramids; Macquer, as hexahedral prisms, terminated by very sharp pyramids; the academicians of Dijon as parallelopipedons with two alternate slopes. It has a cooling taste; it

it is decomposed by the action of fire; it effloresces in the air; it is more soluble in hot than in cold water, and crystallizes by cooling. The acids precipitate acidule from it; lime, barites, strontian and the fixed alkalis separate from it either both bases, or only ammonia.

23. Though, in general, there is little reciprocal action known between the salts and the tartarous acidule, it is probable that there would take place between them, especially those with an earthy base, a great number of effects of double attractions, which it would be useful to appreciate. The nitrates and the superoxigenated muriates decompose it with the assistance of heat, decompose or burn its acid, more or less completely according to the proportion of these salts which is added to it. With the nitrate of pot-ash and crude tartar is prepared an alkali, or rather a carbonate of pot-ash, which was formerly termed in chemistry *white flux*, or *black flux*, accordingly as the one contained only the alkaline carbonate by reason of the complete combustion of the carbon, and as in the other there remained a portion of the carbon of the tartar. These names of fluxes have been given to the products of these operations, because they have been especially destined to serve for fusing the earths of the gangues in the assaying of ores. The black or reducing flux is formed with two parts of tartar and one part of nitre; the white with equal parts of tartar and of nitre, the mixtures being thrown into a red-hot crucible,

ble, in which they detonate and inflame with rapidity. The combustion and detonation of the second is much stronger than that of the first. The term of *crude flux* is applied to the mixture of nitre and of tartar in whatever proportions before it has been made to detonate.

24. The tartarous acidule appears to be capable of uniting with most of the metals, and especially of the metallic oxides, without being decomposed, according to the experiments of Citizen Monnet and the academicians of Dijon. It constitutes a kind of triple salts. Hitherto those only have been examined with attention that take place with the oxides of antimony, of mercury, of lead and of iron; either because these compounds present a greater number of remarkable facts, or because most of them are medicines of more or less importance; that which merits the most attention of all, which is so generally employed that it might be said to constitute a kind of universal remedy, is its union with the oxide of antimony.

25. The names of *stibiated tartar*, *antimoniated tartar*, *tartar emetic*, have been applied to the triple saline combination of the tartarous acidule, and the oxide of antimony. Adrian de Mynsicht was the first who gave an account of it, in 1631. Almost all chemists have zealously occupied themselves with it; but none of them have examined its properties with more attention than Bergman. Every author and every pharmacopoeia has given particular pro-

processes for preparing this important medicine. They differ from each other, both with respect to the species of oxide of antimony which they propose, with respect to their quantity, and that of the water, or of the tartarous acidule, and lastly with respect to the manner of proceeding in its preparation. Bergman, in his Dissertation, has given a very well constructed table of all the processes hitherto described for this preparation. The sublimed white oxides and the vitreous sulphureous oxides have been successively recommended. Some have prescribed ebullition with the tartarous acidule and water for the space of ten or twelve hours; others have indicated only an ebullition of half an hour. Some have recommended to evaporate the filtrated lixivium to dryness; others have prescribed to cause it to crystallize, and to use only the crystals. Accordingly as these different processes have been adopted in different pharmaceutical laboratories, salts very different in their nature and their virtues have been obtained. Thus Geoffroy by examining different stibiates tartars, found them to contain from one-eighteenth to upwards of one-fourth of their weight of oxide of antimony. After a great number of trials, most able chemists have preferred the vitreous sulphurated oxide of antimony, or the *glass of antimony*, to all the other oxides, as it is one of the most soluble by the tartarous acidule. It is boiled with an equal quantity of tartarous aci-

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dule, both reduced to powder, in a sufficient quantity of water, namely, eight or ten times their weight, till the acidule is saturated; there rises a considerably thick scum, charged with yellowish or brown flakes, which are a mixture of sulphur, of tartrite, of lime, and of a little oxide of antimony. Frequently this scum forms a magma, as it were gelatinous, which yields a pyrophoric residuum when distilled. The liquor, which is of a very clear lemon colour, is filtrated; then evaporated with a gentle heat till a slight pellicle is formed, and suffered to cool slowly; regular crystals are formed, which are extracted from it at several times by successive evaporations. Some chemists prefer the oxide of antimony precipitated from the sublimed muriate by water, or the grey sulphurated oxide, for this preparation.

26. This compound is a triple salt, or a tartrite of pot-ash and antimony, which crystallizes in regular tetrahedrons or triangular pyramids, or in octahedrons more elongated than those of alum. It has a slightly metallic and harsh taste: fire decomposes it, disengages from it pyrotartarous acid, and leaves a coal which contains pot-ash and oxide of antimony, and which frequently takes fire by the contact of the air. This salt effloresces in the air, loses its transparency, and becomes of a dull white colour, very brittle and pulverulent. It is soluble in eighty parts of water at fifteen degrees. Boiling water dissolves above one half more of

it. The solution slightly reddens the tincture of turnsole. The earths and the alkalis separate from it a very white oxide of antimony: the alkaline carbonates, a carbonate of antimony in small needled crystals, disposed in rays. The alkaline sulphurets and the hidro-sulphurets form in it a precipitate of an orange colour, or a *sulphur auratum*, the colour of which renders it easy to recognize the presence of this antimoniated salt. The juices of plants, and especially the extractive decoctions of the woods, the roots and the barks, precipitate the solution of tartrate of pot-ash and antimony into a matter of a reddish-yellow colour, which has no longer an emetic quality; and Citizen Berthollet has proposed to destroy, by means of a decoction of Peruvian bark, the bad effects of this salt received in too large quantity, or inconsiderately into the stomach. Several metals, and particularly iron, decompose the tartrate of pot-ash and of antimony, and precipitate the latter oxide. Bergman asserts that it contains nearly a third of its weight of antimony.

27. The tartarous acidule may be combined in two ways with the oxide of mercury; for it has only a feeble action upon this metal, of which it only favours the oxidation into the black state, or the simple extinction. The first consists according to the process of Citizen Monnet, in treating with boiling water, six parts of tartarous acidule, and one part of oxide of mercury precipitated

precipitated from the nitric acid by the carbonate of pot-ash. The filtrated liquor yields by evaporation small crystals of tartrate of pot-ash and of mercury. However this salt is of little permanency, for the same author asserts that it is susceptible of being decomposed by pure water. The second method consists in pouring a solution of tartrate into the nitric solution of mercury; but here only a simple tartrate of mercury is precipitated, and no triple salt is formed, as in the preceding case; the compound formed, belongs therefore to the history of the tartarous acid, not to that of the acidule.

28. A very sensible action takes place between the tartarous acidule and the oxides of lead. Rouelle the younger, has verified, that these oxides have the property of decomposing the tartarous acidule, of taking from it its excess of acid, and of uniting with it into a tartrate of lead, white, pulverulent, and insoluble; of leaving in the supernatant liquor the tartrate of pot-ash, which existed in the tartarous acid; accordingly this chemist has employed this fact for confirming the presence of pot-ash in this acidule.

29. It appears, that the tartarous acidule easily attacks copper and its oxides, and that the result is a triple salt of a fine green colour, susceptible of crystallization, which has hitherto been but little examined.

30. Iron is one of the metals upon which this acidule acts with the most energy, and with
which

which it forms several compounds designed for medicinal use. The *chalybeated tartar* is prepared by boiling in 92 parts of water, four parts of iron filings, and six parts of tartarous acidule. When the acidule appears to be dissolved, the liquor is filtrated; it deposits crystals, and others are obtained from it by continuing the evaporation. The *tartarized tincture of Mars* is the product of a paste made with six parts of iron filings sixteen parts of tartarous acidule, and a sufficient quantity of water, which is left at rest for twenty-four hours, and is afterwards boiled in 92 parts of water for two hours, till it is evaporated to the consistence of a syrup, one part of alcohol being added at the end. It appears that this latter medicine is not a triple salt, as Rouelle asserts, but that the pot-ash exists in it in a free state, and that by treating it with the acids it affords the salts which that alkali always yields. There are also prepared what are termed *steel-balls* (*boules de Mars*), by putting one part of steel-filings, and two parts of white tartar, in the state of powder, into a glass vessel with a certain quantity of spirit of wine. When this is evaporated, the mass is pounded, spirit of wine is added, as at first, and it is left to dry. This process is repeated till the mixture becomes fatty and tenacious: it is then formed into balls.

D. *Uses.*

31. THE tartarous acidule, under the form of crude tartar, white or red, is employed in many of the arts, especially in dyeing, in the felting of hats, in gilding, in docimastic processes, &c. In chemistry it is an extremely useful substance, as I have already shown.

32. In medicine, the purified tartar, or the tartarous acidule, is much employed under the name of *cream of tartar*, as a refrigerant, an antiseptic, and a gentle purgative. It is frequently rendered soluble by the addition of borax, or boracic acid. It cannot be employed as a condiment, on account of its disagreeable taste. However it is used at table in the Northern countries, where it is said to be consumed in large quantities. Most of the products or the triple saline compounds, formed by the tartarous acidule, are also medicines more or less serviceable, and in use.

SPECIES II.

VARIETY II.

*Of the Tartarous Acid.**A. History, Extraction:*

1. SCHEELE first taught chemists the means of extracting the tartarous acid from tartar, and separating it from the portion of pot-ash, which it contains in its state of acidule. He communicated his process to M. Retzius, who published it in the Memoirs of Stockholm for 1770. It is the first discovery that is known of this able Swede. Any given quantity of acidulous tartrate of pot-ash is dissolved in boiling water; carbonate of lime is thrown in till no more effervescence takes place, and till the liquor no longer reddens the syrup of violets. The liquor is suffered to cool, and filtrated; in this manner insoluble tartrate of lime is separated in a white powder, which remains upon the filtre; it is then evaporated, and by evaporation nearly the half of the weight of the acidule employed is extracted in tartrate of pot-ash, or vegetable salt. The tartrate of lime, being well washed, is put into a large glass cucurbit; a quantity of sulphuric acid, equal to that of the chalk employed, and diluted with half its weight of water,

water, is poured upon it. This mixture is digested in a sand-bath for twelve hours, stirring it from time to time with a spatula of wood or glass. The sulphuric acid seizing the lime, forms a sulphate which is precipitated in the place of the insoluble tartrate, and the supernatant liquor contains the tartarous acid free. This is decanted, and after the precipitate has been well washed, and this lixivium mixed with the first liquid, it is tried by the acetite of lead, which forms in it a precipitate entirely soluble in vinegar, if the tartarous acid be pure, but not soluble, if it be mixed with sulphuric acid. In the latter case, it is digested again upon a little tartrate of lime, in order to take away the sulphuric acid that may be contained in it. It is then evaporated, and a little more than one third of the weight of the acidule employed is obtained in concrete tartarous acid.

2. It is probable that this acid exists pure in some vegetables, as Citizen Vauquelin has found about one sixty-fourth of it in the pulp of the tamarind ; but it is so little abundant, and so much enveloped, as it appears, that we cannot yet hope to find means of obtaining it in a direct way, till it shall be ascertained that there exist plants, or parts of plants, in which it is contained in greater abundance than in those from which it has been extracted, or rather which have hitherto presented some traces of it.

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3. Several modern chemists have spoken of the conversion of some vegetable substances, and even of some vegetable acids into tartarous acid; but this has not yet been confirmed by experience; besides which, they have yet prepared so little of it by this artificial process, that it has not hitherto been possible to employ this method for obtaining the acid in question.

4. It is to be observed, with respect to the process of Scheele, the only one that has yet been practised for obtaining the tartarous acid free and pure, that lime may be employed instead of chalk; and that then all the tartarous acid being absorbed by this earth, we obtain more of it on the one hand, and on the other there remains in the liquor which swims above the tartrate of lime only, pure and caustic potash. In order to obtain this acid sufficiently pure, the first crystals are dissolved again in distilled water, and this second solution is evaporated to crystallization.

B. Physical Properties.

5. THE tartarous acid extracted by the process of Scheele has the form of crystals, most frequently in very fine needles, resembling hairs. Bergman has represented them like leaves collected together at one of their extremities, and divergent at the other. Spielman and Corvinus have obtained crystals by cooling, grouped together in the form of plates, some in needles,

needles, others in pyramids. By a slow evaporation of the saturated solution, I have obtained it in irregular hexahedral prisms, but however sufficiently well pronounced. Slow and spontaneous evaporation yields it in square plates a little rhomboidal with oblique edges.

6. It has a very acid and very pungent taste, which strongly sets the teeth on edge, and which is not disagreeable, like that of the tartarous acidule. Diluted with water, it has a taste resembling that of lemon-juice, and may be employed for preparing a good lemonade. It strongly reddens the blue vegetable colours, and is not fusible without alteration.

C. Chemical Properties.

7. WHEN exposed to the fire upon ignited coals, the tartarous acid is fused, becomes black, emits fumes, swells, exhales a pungent acid vapour, burns with a blue flame, and leaves a spongy coal, in which are found some traces of lime. When distilled in a proper apparatus, it affords water charged with pyromucous acid, coloured oil, much carbonic acid and carbonated hydrogen gas; it leaves a voluminous swelled coal, which yields no pot-ash, a certain proof that this alkali is not formed at the expence of the principles of the tartarous acid in the distillation of the tartarous acidule, from the results of which it differs only in the absence of ammonia

monia in its products and of pot-ash in its residuum. Spielman and Corvinus who have carefully distilled four ounces of this acid, concrete and crystallized in the pneumato-chemical apparatus, have obtained 431 cubic inches of carbonic acid gas, and 120 inches of carbonated hydrogen gas.

8. Amongst the products of this decomposition of the tartarous acid by fire, that which characterizes it the most, and belongs to it in a specific manner, is the acid water which is obtained in the same manner as from the acidule. This is the pyrotartarous acid, the distinctive properties of which I shall here enumerate. The tartarous acid furnishes more of it than the acidule; it amounts to at least one-fourth of the weight of the first; it is a reddish liquor which is separated from the oil by the funnel. It cannot be rectified by distillation without breaking the retort, by the kind of explosion which it presents, according to the academicians of Dijon. It has a slightly sour taste, and produces a disagreeable impression upon the tongue. It is strongly empyreumatic; it reddens turnsole, but not the tincture of violets; it disengages the carbonic acid from the earthy and alkaline carbonates with energy; it forms with the alkalis soluble and crystallizable salts. Its saline combinations are not well known, neither are those which it is capable of affording with the oxides of the metals; it precipitates the nitric solution of silver in a white-grey powder; that

that of mercury in a white powder, which is but slowly deposited; that of lead, likewise white. The attractions of the pyro-tartarous acid are not yet known; and the little that is hitherto known of its properties is merely sufficient to distinguish it from all the other acids, and to show that it is neither the nitric nor the muriatic acid, as was at first imagined by some chemists. It is only evident that this acid is a simple modification of the tartarous, that, like it and the other vegetable acids, it is composed of carbon, hydrogen, and oxygen, and that it differs from it by the proportion of its principles, and especially by the larger quantity of hydrogen.

9. The tartarous acid is not altered by the action of the air; it is much more soluble in water than its acidule, as Bergman has made a solution of it, the weight of which was to that of water as 1230 to 1000. It is obtained separate and crystallized by the evaporation of its water of solution, whether this be effected by artificial means, or suffered to take place spontaneously. This solution is not altered nor decomposed spontaneously except when it is diluted with water; when concentrated, it loses nothing of its acid nature or of its properties.

10. Bergman believed that the tartarous acid was unalterable by the powerful mineral acids, and especially by the nitric acid; but Mr. Hermstaedt has effected its conversion into
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oxalic acid, by distilling it several times successively with six times its weight of nitric acid; 360 parts of tartarous acid afforded him 560 parts of crystallized oxalic acid; which indicates the fixation of a large quantity of oxygen.

11. The tartarous acid forms with barites and lime insoluble, pulverulent, white salts, which are, however, dissolved by the aid of an excess of their acid, and are decomposed by the mineral acids. These two bases have not only more attraction with the tartarous acid than all the others, but Bergman places magnesia before the alkalis in his table of elective attractions. The tartrate of lime serves, as we have seen, for extracting the tartarous acid by means of the sulphuric acid.

12. The combination of the tartarous acid with magnesia and alumine yields no crystallizable salts but gelatinous or gummy masses. Citizen Vauquelin, by examining the sulphate of strontian found at Bouvron in the department of la Meurthe, and the combinations of the base which he has extracted from it, says that the tartrate of strontian formed by the union of the muriate of this earth with the tartrate of potash, is soluble, and crystallizes by the heat of ebullition, that it contains 52,88 of strontian and 47,12 of acid.

13. When we unite tartarous acid with potash, soda or ammonia, employing a proportion of the base less than is required for its saturation.

faturation, there is precipitated in the three combinations an insoluble acidule, which each of the bases has the property of forming. The differences which each of these acidules presents have not yet been examined; and their analogy has only proved that the tartarous acid, in its semi-faturation by each alkali, becomes infinitely less soluble than the acid alone is, or its entirely faturated combination with any of these three alkalis. These acidules all resemble each other in being equally decomposable by the powerful acids, all which have less attraction with the alkalis than the tartarous acid has with the first portion that unites with it.

14. The tartarous acid, combined with pot-ash, and entirely faturated, forms a soluble salt, which was formerly termed *soluble tartar*, or *vegetable salt*, and which is designated in the new nomenclature by the name of *tartrate of pot-ash*. We have seen above that the tartarous acidule, which is merely tartrate of pot-ash with excess of acid, affords the same salt by the addition of pot-ash: I have already indicated it, and have announced that I should speak of it in the history of the tartarous acid. I shall, therefore, here explain its principal properties. It is prepared by throwing tartarous acidule into a hot solution of carbonate of pot-ash: a lively effervescence takes place by the disengagement of carbonic acid. Acidule is continued to be thrown in, till the liquor is saturated, and no longer

longer produces any effervescence; it is boiled for the space of about half an hour; then filtrated, and afterwards evaporated to the formation of a pellicle, and suffered to cool slowly; crystals are formed in it in long squares terminated by two oblique faces. This salt has a bitter taste; it fuses, swells and blackens upon ignited coals. It yields pyromucous acid, oil, and much gas by distillation; it leaves a large quantity of alkali in its coal; it attracts in a small degree the humidity of the atmosphere; and is soluble in four parts of water at forty degrees. Its solution when kept for some time is decomposed, deposits mucous flakes, and leaves oily carbonate of pot-ash in the water. Lime, barites, strontian, and probably magnesia decompose it. The three first bases form in it an abundant precipitate. The mineral acids separate from it the excessive portion of pot-ash beyond the state of acidulous tartrate, and precipitate this acidule from its solution; heated with it for a long time and violently, they take from it the whole of the pot-ash by altering its acid: it decomposes most of the metallic solutions. The tartarous acid, added to the solution of tartrate of pot-ash, changes it into tartarous acidule which is quickly deposited in small crystals.

15. The saturated combination of tartarous acid and soda, or the pure tartrate of soda, is much less soluble than the salt of Seignette or the triple tartrate of pot-ash and soda; it crystal-

lizes in very fine needles or in thin plates, and not in large prisms of eight sides like the latter. Besides this is proved not to be the real salt of Seignette by the circumstance, that when a solution of tartrate of pot-ash is mixed with a solution of this pure tartrate of soda, provided that both have been concentrated without, however, crystallizing, we immediately obtain crystals of this salt of Seignette, or of tartrate of pot-ash and soda in prisms of eight sides, like those of this triple salt.

16. The ammoniacal tartrate, or the tartarous acid saturated with ammonia crystallizes well. This bitter salt is very soluble and decomposable by fire, by barites, strontian, lime, magnesia, and the two fixed alkalis. The powerful acids precipitate from it an acidulous ammoniacal tartrate. Its solution is also spontaneously decomposable with the aid of lime.

17. The tartarous acid decomposes all the alkaline salts, and takes from them the portion of pot-ash, of soda and of ammonia which it requires for forming acidules. It precipitates the nitrate, the muriate, and the acetate of lime from which it separates this earthy base. It is evident that it is by no means so weak as was formerly believed, since it has more strength than the mineral acids.

18. There are but very few metals upon which it exerts an immediate action; but it unites with the most of their oxides.

A. The tartrites of arsenic, of tungsten, of molybdena, of chromium, of titanium, of uranium, of cobalt, and of nickel, are not yet known.

B. It forms with the oxide of manganese, from which it disengages a portion of the oxygen, a limpid solution.

C. It does not act upon antimony, even with the aid of heat; it combines well with its oxides, especially the vitreous sulphuret or glass of antimony, and the powder of Algaroth; it forms a tartrite of antimony, which crystallizes but very little, very irregularly, and which yields, for the greater part, a gelatinous matter: whence it follows that this combination, so different from the antimoniated tartrite of pot-ash, cannot be substituted in its place.

D. It has no effect upon bismuth, but it takes its oxide from the nitric solution, and forms a tartrite of bismuth precipitated in a white and insoluble powder.

E. The tartarous acid, when triturated dry or liquid with mercury, favours its extinction, or its oxidation into the black state. It unites with its red oxide which it whitens; it decomposes and precipitates the nitrate of mercury, and forms, with its oxide, an insoluble tartrite of mercury, which quickly becomes yellow by the contact of the air and of light. It acts neither upon the sulphate nor the muriate of this metal.

F. It attacks zinc in an active and powerful

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manner, which presents, by its contact a rapid effervescence and disengagement of hydrogen gas. The tartrite of zinc which is formed has not yet been examined.

G. It has no direct action upon tin, or upon lead, though it appears to combine with their oxides. It whitens, by mere contact, the red oxide of lead. It decomposes and precipitates the nitrate and the muriate of the latter metal into a white insoluble tartrite.

H. It acts upon iron as upon zinc, dissolves it with effervescence and disengagement of hydrogen gas, and affords a red solution which assumes the form of a gelatinous mass without crystallizing. Poured into the solution of sulphate of iron, it does not precipitate it; but when the mixture is heated, according to M. Retzius, it seizes the portion of oxide which detaches itself from this salt, and forms with it lamellated crystals, little soluble, which, according to the same chemist, are not precipitated by the prussiates, unless acid of nitre is added.

I. Without sensibly altering copper by its first contact, it unites with its oxides and forms a salt of little solubility, of a green colour. Mr. Parker has observed small, green, irregular crystals formed at the bottom of the nitric and muriatic solutions of copper, into which he had poured tartarous acid, which had produced no sensible effect at the first moment when it was mixed with them.

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K. It does not attack silver, or gold, or platinum, nor does it precipitate the nitric solution of the first, or the nitro-muriate of the second. However, the saturated salts effect these precipitations, like that of all the other metallic salts, by a double attraction.

L. In general all the metallic tartrites, most of which are pulverulent and little soluble, yield pyrotartarous acid by distillation, are decomposed by the earths and the alkalis, form many triple tartrites, by the addition of a small proportion of the latter, and always yield their oxides to the sulphuric acid, sometimes to the muriatic, rarely to the nitric. None of them have yet been employed.

19. The tartarous acid is one of the strongest vegetable acids; it yields only to the oxalic acid. Compared with the other vegetable acids, it appears more especially to differ from them by the proportions of its principles, and especially by that of the carbon. Citizen Vauquelin and myself have found in our analyses, that 100 parts of this acid contain 70,5 of oxygen, 19 of carbon, and 10,5 of hydrogen. Hence it appears to follow, that in order to convert it into oxalic acid, it is only requisite to take from it 6 parts of carbon, and to add to it 6,5 of oxygen, without at all changing its proportion of hydrogen, which is the same as in the oxalic acid.

D. *Uses.*

20. Not much use has yet been made of the pure tartarous acid, though known since 1770: it has hitherto been prepared, almost exclusively, in the laboratories of chemistry, in order to determine its properties and nature. It may, however, be employed as a cooling, antiseptic, and antifebrile drink; and, in the *War of Liberty*, a pretty considerable and very advantageous use was made of it in the military hospitals of the French Republic. Diluted with water, and sweetened with sugar or honey, it forms a very agreeable and wholesome kind of lemonade—a convincing proof that the faint and unpleasant taste of the tartarous acidule depends intirely upon its semi-saturation with pot-ash. As this acid may become so useful an object, it is essential to add an improvement, small indeed, but useful, to the art of refining the tartar, to that of preparing pharmaceutically its saline and medicinal combinations. It has been seen that there is separated, in these operations, at least 0,07 of cream of tartar, and consequently a much larger quantity of tartrate of lime in an insoluble powder, or a viscous paste of tartar, and that this matter has been well examined by Citizen Vauquelin. It will henceforth be advisable to collect it in the abovementioned operations, to wash it well, to treat it with the sulphuric acid diluted with water, and to extract from it the pure tartarous acid,

acid, which will be easily kept, and exhibited in the solid and crystalline form, or by giving it the nature of a syrup with the addition of sugar, it may be substituted in place of the syrup of lemons.

SECTION IV.

Of the Third Genus of Vegetable Acids, or of the Empyreumatic Acids.

1. I HAVE already shown that a great number of vegetable substances, heated in close vessels, yield by distillation, acid liquors which did not exist in these substances previous to the action of the fire, and that this agent really produces them. It is not necessary here to return to the explanation of this phenomenon, or to repeat, that it is by a change amongst the principles, and by a particular combination between the hydrogen, the carbon, and the oxygen, that this production of the empyreumatic acids takes place.

2. It is more essential to remark that these acids, though different from each other, have, nevertheless, some generic characters by which they approximate to each other. They derive these characteristic properties from the very nature of the phenomenon which has given rise to them; they have all a burned taste, a particular fetid acrimony, which chemists long termed *Empyreuma*. It is manifestly the same as that which distinguishes

distinguishes the oils produced by distillation, which are also designated by the expression of empyreumatic oils. We also see that the substances that afford these acids are at the same time susceptible of yielding empyreumatic oil, and that the substances which yield no oil do not furnish acids. It is in this manner that the citric acid, and especially the oxalic acid, which present no trace of oil in their distillation, likewise present none of acid, whilst the tartarous acid, from which a very sensible quantity of oil is extracted, yields at the same time pyrotartarous acid.

3. Hitherto only three empyreumatic acids are known; though it is very probable that several others will be found by examining well the products of a greater number of vegetables than has hitherto been done, especially when we reflect that chemists, whose attention has long been engaged by the property which vegetable substances possess of affording acid liquors by distillation, have thought it one of the characters the most proper for distinguishing these matters from the animal substances.

The three species of empyreumatic acids hitherto known, are the *pyromucous*, the *pyrotartarous*, and the *pyroligneous*.*

* Though these acids are now known to be the acetous slightly altered by oil, I have not thought fit to omit the subsequent species. See appendix.

SPECIES I.

Pyromucous Acid.

1. I HAVE already described this acid in the history of the mucous bodies and sugar to which it belongs, as a constant product of the action which fire exerts upon them. I shall here repeat nothing concerning its properties, except what may serve to characterize it, by comparing it with the two others, and what belongs to its formation. Both these considerations must conduct us to a better knowledge of the nature of its products, and the characters by which they approach to, or are removed from the other genera of these compounds.

2. As to the origin, or the formation of the pyromucous acid, by collecting under the same genus the different immediate materials of vegetables which afford this species of acid by distillation, or the action of fire in general, gum, the mucilages, the saccharine substances, and the amilaceous fecula, we see that they have four very distinct and very remarkable properties: the first, that they are sweet, tasteless or insipid; the second, that they form, with hot or cold water, gelatinous bodies; the third, that they contain and yield much coal in their analysis; the fourth, that they are all converted into malic and oxalic acids, and some of them at first into mucous or saccharylactic acid. It is
very

very evident, that these four properties agree well with that of affording pyromucous acid, that they depend upon the same cause, upon the same primitive composition, upon a very near relation between the proportions of their elements.

3. The pyromucous acid is characterized by its reddish or brown colour, its pungent taste, which, though empyreumatic in general, is different from that of the two other acid products of fire, its smell equally distinct and particular, its property of staining the skin red, the salts which it forms with the different bases, its attractions for those bases, and the coaly mark which it always leaves upon the vessels in which it is heated. It cannot be doubted that it consists of carbon and hydrogen combined with oxygen, though the proportions of these principles are yet unknown. It is known that by its last decomposition it yields water, carbonic acid, and insulated coal.

SPECIES II.

Pyrotartarous Acid.

1. THE tartarous acidule, and the acid which is extracted from it, afford, as I have already mentioned, a particular acid by distillation, and this acid has no more analogy with that from which it proceeds, than is found between the pyromucous

cous acid and the substances which furnish it. I have indicated the characters of this empyreumatic acid; we have seen that its smell, its taste, and especially the salts which it forms with the earthy, alkaline, and metallic bases, distinguish it from all others, and have induced chemists, at all times, to acknowledge it as a particular product.

2. What is very remarkable in the production of this pyrotartarous acid, is that it is furnished only by the tartarous acid, and by the compounds into which it enters. The cause of this phenomenon, by which the pyrotartarous acid also differs greatly from the pyromucous, will be found when the analysis of these two acids shall be made, and the proportion of the principles that enter into their composition determined.

SPECIES III.

Pyroligneous Acid.

1. THE pyroligneous acid resembles the pyrotartarous acid in the circumstance that there is only one particular vegetable substance that furnishes it by the action of the fire: this is the ligneous matter, or wood, as its name expresses. I shall not treat farther concerning this acid in this place, as its history ought to be placed under that of the ligneous matter to which it belongs. I shall only observe, that the pyro-
ligneous

ligneous acid, afforded by all distilled woods, is well characterized by its particular smell, its colouring property, and the salts which it forms with the earths and alkalis. The difference of this acid, from the two preceding, depends upon the primitive nature of the ligneous substance, which is very different from that of the mucilages and the tartarous acid.

SECTION V.

Of the Fourth Genus of Vegetable Acids; or of the Factitious Acids, which have not hitherto been found in Nature.

1. IN the ingenious method of treating the vegetable substances by the powerful acids, and especially by the nitric acid, discovered in 1776, by the illustrious Bergman, these substances are converted into several acids, which did not previously exist, and I have shown that this conversion is owing to the change of the proportion of the principles, occasioned by the oxygen of the acid, which seizes the vegetable substance. In this mode of action, which is explained by the pneumatic doctrine, there are two kinds of acid formed; the one are entirely similar to the acids found in the vegetables; the others, on the contrary, are altogether different from those which are found in the different ve-

getable substances, or at least from those that have hitherto been found, for we must not confound the limits of art with those of nature. These form the fourth genus which I distinguish.

2. It is not difficult to conceive, from what I have hitherto shown, that they derive their origin from a matter, or from some matters originally different from those which afford the following; and in fact one of them, though it may proceed from several analogous matters, has however, in some measure, a strict limit of formation; this is the mucous or sachlactic acid; the two others are produced severally by one of the particular matters, which are termed immediate materials of vegetables; the one with camphor, which on that account is termed camphoric acid; the other with the cork or the epidermis of the barks, which I term in general *suber*; and on account of this origin the acid is termed the *suberic acid*.

SPECIES I.

Mucous Acid.

1. I HAVE already given, in the history of gum, an account of the properties of the mucous, or sachlactic acid: without returning
again

again to what I have said concerning it, I content myself with repeating that the insipid mucilages are the only substances that furnish this acid, which was first discovered by Scheele, and which he for some time thought to be peculiar to the sugar of milk; that the saccharine matter does not furnish it by the action of the nitric acid, and that it is distinguished from all the other artificial acids by its pulverulent state, its little solubility, its weak taste, and by its saline compounds.

2. The exact proportion of its principles has not yet been ascertained, nor is it known how far it differs in this respect from all the other vegetable acids. It may be supposed to contain a very large proportion of carbon, and that to the superabundance of this principle are to be ascribed its dry state, its insipidity, its insolubility, its inalterability, and all the other properties by which it is characterized.

It is, therefore, an acid hitherto too little known, and which deserves to be examined with great care, especially in its comparison with the other species of acids with binary radicals, with hydrogenated carbon, or carbonated hydrogen.

SPECIES II.

Camphoric Acid.

1. THIS is never formed except at the expense of camphor; I refer its history to that of this substance; I shall here only observe, that being produced by a strong and long continued action of nitric acid, it enjoys properties well characterized as a peculiar acid; that it approaches in its nature to the benzoic acid, with which it has even been confounded by several modern chemists; but that it would differ from it, had it no other distinctive property than that of not being separated from its solution in alcohol by water, whilst the benzoic acid is very easily separated in this manner. Besides which I shall hereafter show it to possess many other characteristic properties.

SPECIES III.

Suberic Acid.

1. THE same is the case with the suberic acid, the constant production of the action of the nitric acid upon cork: when once formed, it enjoys

enjoys properties which distinguish it from all other artificial acids. Its smell, its decomposition by fire, its manner of separating from a fatty substance at the moment when it is formed, are characters well pronounced, and well distinctive of its species, not to mention other individual properties belonging to it, of which I shall treat hereafter.

SECTION VI.

Of the Fifth Genus of Vegetable Acids; or of the Artificial Acids resembling those of Nature.

1. I CANNOT dwell too much upon, or revert too often to the important discovery of artificial acidification, and the approximation which exists, if not between the processes, at least between the results of the efforts of art, and of the operations of nature. It is extremely striking in the conversion of the not acid vegetable matters into acid substances, perfectly similar to those created by vegetation. This identity proves that the change that has taken place in these matters, at the time of their artificial transition into the state of acids, is the same as that which they experience in nature.

2. Three

2. Three vegetable acids formed by the efforts of art have been discovered : besides the oxalic acid, which was at first termed acid of sugar, and found perfectly analogous to that of sorrel, &c. the malic and the tartarous acids have been enumerated in this order. I shall here say a few words concerning each of these factitious acids, of which I have already spoken, or which I have described as native acids.

SPECIES I.

Factitious Malic Acid.

1. SCHEELLE was the first who asserted that he had converted the insipid, or not acid vegetable substances into malic acid. He even found that all those that yielded oxalic acid by the nitric acid, were at the same time capable of furnishing malic acid. Mr. Hermstaedt has since considered the factitious malic acid as a kind of preliminary to the oxalic acid, as on the one hand it is produced at the same time with it, and on the other capable of passing to the state of oxalic acid.

2. Since the time of Scheele, it has been discovered that the oxygenated muriatic acid possesses the property of converting the insipid vegetable substances into malic acid much

more speedily than is done by the nitric acid, that this conversion is more permanent, that it passes less easily into the state of oxalic acid, than when it is produced by the action of the nitric acid. It is sufficient to throw gum in the state of powder into the liquid oxygenated muriatic acid, and to stir it therein for some time, in order to convert it into malic acid.

SPECIES II.

1. THE opinion of the possibility of forming the tartarous acid artificially, rests upon the authority of Messrs. Crell and Hermstaedt. They have asserted that they have succeeded in effecting this decomposition by means of the nitric acid; but no chemist has spoken of it since, or confirmed their first result. The possibility of the circumstance, however, cannot be denied, unless we have exact experiments to oppose to their assertion; and there is nothing to oppose the possibility of this acid being formed by the efforts of art, as several others are formed.

SPECIES III.

Factitious Oxalic Acid.

1. OF all the acids that exist in nature, this is the most easily and most abundantly imitated or fabricated by art. Besides the mucus and the sugar, whose conversion into this acid by means of the nitric acid I have already indicated, we shall see hereafter, that a great number of vegetable and animal substances equally possess the property of furnishing it by the action of the same acid. I have already fully examined its properties, I shall here only add its most distinctive characters founded upon its crystallizability, its rapid decomposition into water and carbonic acid, its attraction for lime superior to that of all the other acids, and the insoluble salt which it forms with this base, whether it be combined with it in an immediate manner, or whether it takes it away from any other acid.

SECTION VII.

*Of the Sixth Genus of Vegetable Acids; or
of the Acids produced by Fermentation.*

1. NOTHING is more common than to see vegetable matters become spontaneously acid, by a proper intestine motion of their own substance. Besides the amylaceous fecula, the vinous liquors, &c. the stalks, the leaves macerated in water, speedily assume the acid nature; and the roots undergo the same alteration. These are real fermented acids that are formed under these circumstances, and there has even been deduced from their formation a well-marked character of the vegetable substances, by calling them *acescent*.

2. Notwithstanding the multiplicity of vegetable substances that become acid by fermentation; notwithstanding the very natural presumption which leads us to believe that several different acids are formed by this intestine motion, only two acids have yet been distinguished amongst these products. And one of the two, the acetic acid, is merely a modification of the acetous.

SPECIES I.

Acetous Acid.

1. AS the properties of this acid will be explained in detail in the article concerning the acid fermentation, I shall content myself in this place with observing that this acid is not constantly the product of fermentation; that it is not always the effect of the founness of wine; but that it frequently proceeds from the alteration produced in vegetable substances by the sulphuric or muriatic acid.

SPECIES II.

Acetic Acid.

1. THOUGH the acetic acid, the history of which will follow that of the preceding, is ranked here as a product of fermentation, it is merely a consequence of acidification, and it succeeds the formation of the acetous acid; from which, as shall be shown hereafter, it differs only by a particular modification.

ARTICLE VIII.

Of the Fifth of the immediate Materials of Vegetables: of the Fecula.

A. Situation.

1. THE name of fecula is applied in chemistry to the dry, pulverulent and especially white matter, which is precipitated from water in which several parenchymas of vegetables have been steeped. Though this name has also been given to the fibrous substances which impair the transparency of the expressed juices of plants, after the Latin word *ſæx fæces* (*ordure*), and though it is in conformity with this expression that the juices are said to be *defecated*, in order to deprive them in fact of their fecula, yet these remains of vegetable fibres, which belong to the ligneous matter, are at present no longer confounded with the fecula properly so called. On this account it has been proposed to designate this by the expression of *amylaceous fecula*, because starch is in fact the first and the most known of these substances.

2. The fecula properly so called, or the amylaceous fecula, is met with in different organs of vegetables; it exists in all the tuberous roots, such as those of the potatoe, of the orchis, of
briony,

briony of manioc, &c. It is evident that the class of these feculent roots must be extremely numerous and varied, and that in general we may recognize them by their brittle, seemingly granulated parenchyma, easy to be bruised, and reduced into a soft paste under the finger, and presenting in this paste, when exposed to a strong light or to the rays of the sun, a brilliant, silky, or silver-like texture. We may also convince ourselves of the existence of the fecula in roots, by the property which they have, when they have been bruised, of giving to water in which they are agitated a milky opacity, as I shall soon show more fully. Lastly, these roots, more or less charged with fecula, are also characterized by the property of becoming brittle, and more or less transparent, when they are dried, either by exposure to the rays of the sun, or by the heat of a moderately warmed stove.

3. There are some stalks of plants, or rather trunks of trees, which contain a more or less considerable quantity of fecula, such is especially the trunk of the palm tree, and undoubtedly of a much greater number of trees or plants which are not yet known, and which furnish in some climates an abundant nutriment to men and animals. There are as yet only some species of the palm, and especially the trunk of the *cycas circinnalis*, from which the nations of Asia known by the European travellers and philo-

philosophers derive a considerable quantity of fecula, as I shall show hereafter.

4. In the enumeration of the vegetable parts which afford fecula, I must not omit observing that none of it is extracted either from the leaves or the flowers, and that what is sometimes termed fecula, and is separated from the juice of the first of these organs, is only a detached portion of the fibrous texture or of the ligneous substance which impaired its transparency; accordingly, as I have already indicated, this fibrous fecula ought not to be confounded with the real amylaceous fecula; and nothing is more proper for well fixing their difference than the proposition that neither the leaves properly so called, nor the flowers, contain any of the latter.

5. Some fruits, and especially all those that are fleshy, parenchymatous, brittle, susceptible of being dried or baked, and softened by hot water into a kind of semi-transparent jelly, contain a more or less considerable quantity of real fecula, though chemists have hitherto scarcely remarked it, because they knew that it is not extracted from them, and that it cannot be prepared and employed like the other fecula. And in fact, these fruits are at the same time more or less pulpy, saccharine, mucous, and mixed with so large a quantity of insipid or saccharine mucilage, with which the fecula intimately adheres, that it would be difficult to extract it from these mixtures for economical
uses :

uses: but it is, nevertheless true, that when these soluble and viscous substances have been extracted by chemical operations, by accurate pressure and washing, there remains a white matter, in a brittle paste, still mixed with fibrous and ligneous matter, but which contains amylaceous fecula, more harsh and crude indeed than that which is furnished by the other parts of plants.

6. The seeds or the grains seem to be the vegetable organs in which nature has deposited the largest quantity of amylaceous fecula; and as it is in these substances that animals find the most abundant nutriment, we also find by observation that this matter is destined by nature to serve as aliment to the vegetable embryo. There are even some seeds, especially those of the gramineous plants, which seem to be entirely formed of this feculent matter: accordingly, it is from this kind of parts that the most pure and the most abundant starch is extracted. In many other grains the amylaceous fecula is mixed with colouring parts, extracts, mucilage, or oil. In this consists the chemical difference which exists between the different kinds of seeds.

7. Lastly, there are some species of vegetables, the whole of which and all their parts appear to be tissues of feculent matter, or to contain such an abundance of it that they serve entirely to form real farina. Such the genus of lichen appears especially to be, amongst the
species

species of which are particularly distinguished the *Lichen Islandicus*, of which a kind of bread is formed in Iceland, and the *lichen rangiferinus*, which so easily nourishes the rein-deer. Such appear to be also several species of ferns, the stalk or the roots of which furnish the inhabitants of several of the South-Sea islands with a food which much resembles our farinaceous aliments, and is converted, by baking, into a kind of cake or agreeable paste, similar to our bread prepared from grain.

B. *Extraction.*

8. THE amylaceous fecula is extracted by simply pounding the vegetable parts that contain it, and agitating these pounded parts in water. The fecula is often found to be mixed with two kinds of substances: the one soluble in water, which remains dissolved in the supernatant liquor; and the others, not being soluble in this liquid, are parenchymatous, fibrous and woody. The latter, which are much heavier and much grosser than the fecula, are first deposited in flakes, and leave the starch suspended, in a very fine and very light white powder in the water, which is then turbid like milk.

9. In order to separate this parenchymatous, gross and heavy matter from the pulverulent fecula, which is capable of being suspended for a very considerable time in water, a very simple and commodious means is employed. After
having

having rasped the feculent root, the flaky pulp which proceeds from it is put upon a rather close hair-sieve ; water is poured upon this pulp, which is worked with the hand, and rubbed with a rounded spatula. The water, interposing itself between the particles of this parenchymatous pulp, and being every where in contact with it, detaches from it the fecula with which it is enveloped, and carries it along with it through the meshes of the sieve. This washing and agitation is continued till the water runs off without opacity, that is to say, till it has carried away all the fecula : there then remains upon the filtre a parenchymatous grey or semi-transparent portion. The water which passes through the sieve falls into the vessel, in which it is received turbid and white like milk ; it deposits in the course of time all the fecula which it contains, in a white layer which occupies the lower part of the vessel, and diminishes in thickness in proportion as its particles approach each other, but remains thick and like a very fine paste, on account of the water which it retains between its particles. The water that has become clear at its surface is poured off ; the fecula is dried after it has been cut into fragments, which are spread upon pieces of blotting paper ; when it is sufficiently dry to be easily divided by the pressure of the finger into a fine and soft powder, it is properly prepared.

10. This operation is most frequently performed in the large way for the purposes of life, and

and then it is practised in rasping mills moved by handles, or even by water: in this manner the potatoe is treated. As to the farinaceous grains which are almost entirely composed of amylaceous fecula, it is almost always thought sufficient to bruise them under mill-stones moved by the wind, water, or fire-engines. This ground corn yields the farina, and is separated more or less easily from the bran or the skins bruised by the mill-stone, according to the kind of grain which is employed. However this farina is not considered as pure fecula; it is necessary to wash it with water, and suffer it to deposit the starch which this fluid dilutes and carries with it, in order to separate it from the portion of soluble and insoluble matters which it contains, and of which I shall speak hereafter.

11. It is easy to see, that according to the greater or less purity of the fecula, or according to its natural mixture with different substances, such as the mucilages, the saccharine bodies, the extracts or the colouring parts which it contains, it requires to be treated by a more or less careful or repeated washing; the water dissolves these foreign substances and thus retains them, suffering the fecula to be precipitated. By evaporating the liquid, by means of fire, we collect these soluble substances, discover their nature, and determine their quantity. In the process of the purification of the fecula, the washing is continued
till

till the water employed has neither colour nor smell. There is no feculent vegetable matter, however acrid, however bitter, however coloured it may be, which will not by this means yield pure and white fecula. In this manner starch is extracted in considerable purity from all the farinas of leguminous seeds, yellow, green, or fawn-coloured, and even from the acorn and the horse-chestnut, which however are of all the seeds those which contain the most matter foreign to this vegetable principle, and of an acrid, acerb, bitter, or disagreeable taste. There are a great number of substances which, if treated in this manner, might become useful, but which have not hitherto been employed for this purpose.

12. When the fecula is accompanied with oily substance, which is especially the case in the grains of the cruciferous plants, in the seeds of the syngenesian compounds or plants, in the kernels of stone-fruit, in the seeds of the cucurbitaceous plants, &c. we begin, in order to extract it, with the expression of the oil, as shall be shown in the history of this last substance. When the oil has been separated, the paste or the cake which comes out of the press is washed with water, as the pulps of the roots the stalks, the farinæ of the gramineous plants are treated; and in fact, when once exhausted of oil, the parenchyma of the seeds, which are in general called *emulsive*, suffers its fecula to precipitate from the water; whereas, previous
to

to the extraction of the oily substance, it remains suspended with the oil in the state of emulsion; however there is a part which is attached to the parenchymatous portion of these seeds that does not enter into the emulsive liquor.

13. The advantageous effects of the employment of water in the separation and purification of the fecula will be still better conceived, when it is remarked, that we may thus even obtain it pure, wholesome, mild, and alimentary, from the midst of the most acrid and poisonous pulps, without its retaining any thing of the deleterious property of the pernicious juice, or extract which accompanies it. In the distinction of the species I shall especially apply this remark to the fecula of briony, that of the manioc, &c.

C. Physical Properties.

14. The fecula thus extracted, prepared and purified, is a white powder of a faint taste, or almost without any, very little or very slightly pasty in the mouth, more or less adhesive to the tongue and palate, light and soft under the finger, dividing itself very easily, attaching itself sensibly to the skin, to which it adheres when applied to it rather strongly.

15. When viewed with attention, especially while the rays of the sun fall upon it, or with a good magnifying glass, we perceive

it to be formed of small transparent globules, brilliant, silvery, silky in their mass, and resembling a kind of crystalline matter : when compressed with force, it emits a slight sound, a peculiar kind of crackling, which every one must have observed in fine and well prepared powder.

16. It floats upon water, appearing at first not to become moistened, and is penetrated by that liquid but very slowly ; it even possesses when thrown upon this liquid, a kind of oscillatory or rotatory motion, which continues a long time, and does not cease till oil is applied to the surface of the water, or till it is entirely impregnated with this liquid.

D. Chemical Properties.

17. It must first be observed, in order to understand the chemical properties of pure fecula, that, from whatever vegetable matters it is extracted, whatever coloured or sapid admixture it had at first, it is always the same with respect to its intimate nature, and that it is an absolutely identical body, to whatsoever plant it may have belonged. It presents only some differences of whiteness, fineness, apparent texture, or lightness ; but its intimate qualities or its nature present none.

18. Well purified starch, which I shall take as an example of the genus, when exposed to the fire and air, upon an ignited coal, becomes coloured,
passes

passes through the shades of yellow, orange, red, and brown, before it becomes black; is softened, swells, exhales a pungent white fume, of a not disagreeable acid smell, analogous to that of mucus and of sugar. The coal which is thus formed is a little more voluminous than the substance itself was, though sensibly less so than that of gum. When distilled with a pneumato-chemical apparatus, water is obtained charged with pyromucous acid, some drops of red or brown oil, much carbonic acid, and carbonated hydrogen gas. This last burns with a light blue flame, and in a rapid manner; its flame, when it is kindled in a narrow and long bell-glass, descends horizontally in the vessel; there remains a coal of a single piece, a little spongy, easy to be burned, which leaves only some traces of pot-ash and of lime; the latter is united with phosphoric acid. This analysis resembles that of the mucus.

19. Starch does not appear to experience any considerable alteration by exposure to the air; through it attracts moisture; it collapses and becomes in the course of time fatty and viscous, as it were, and contracts a sour taste, with a smell as if rancid; but it requires a great length of time before this effect is produced. There is no mutual action between starch and the simple combustible bodies.

20. It may be diluted in pure and cold water, by motion and agitation; and forms with it a kind of paste without cohesion, and not ductile, which

which dries and cracks in the air. When a larger quantity of liquid is added, the starch remains for some time suspended in it, and appears like a kind of thick milk. If we suffer it to remain in this state with the water at a temperature that exceeds fifteen degrees of Reaumer, it ferments, rises, becomes a little heated, and turns sour. These phenomena take place in a much more speedy and powerful manner, when it contains some foreign principles, such as the gluten, or an extractive and colouring matter: thus the farina of corn ferments, and becomes spontaneously sour in the process of starch-making; but in this work itself, the portion of starch which escapes acescency, is separated more pure and white from the different foreign matters that were united with it. It is believed that the acid which is formed in this case, and which exists in so marked a manner in the sour water of the starch-makers, is acetous acid; though I do not know that it has been submitted to a particular examination.

21. Boiling water acts upon starch in a very different manner. At this temperature, the whole of the fecula is dissolved in the liquid; it forms a kind of gelatinous transparent substance. On this account the product of this operation is termed potatoe-jelly, when it is made with the fecula extracted from that root. This property is the distinctive character of pure fecula. There is no fecula, from whatever vegetable matter it may have been taken, which

does not present it in a more or less marked manner, and which is not easily recognizable by the gelatinous and transparent consistence which it assumes by this operation. It then becomes very similar to a mucilage, and appears to pass into the mucous state. In fact, if we expose to a gentle and sufficiently continued heat, this species of vegetable jelly, it thickens, dries, becomes brittle, retaining a semi-transparency, and greatly resembles a gum, all the products of which it affords. In this state it is very difficult to distinguish it from the mucous substance, and it deviates from it only by very slight differences: accordingly, most chemists have been led to consider the fecula as a kind of mucilage condensed, become dry and pulverulent, and insoluble in cold water, by the progress of vegetation itself, susceptible of repassing into its former state by the combined action of caloric and of water. This opinion becomes very probable when we observe that the vegetable substances most susceptible of becoming charged or filled with starch, present, previous to its formation, a kind of transparent jelly, which becomes white like milk, afterwards thickens, condenses, and dries in proportion as its maturity advances. The accuracy of this observation is known in all the cereal grains, and in the emulsive seeds, which pass through the successive states of jelly, of thick milk, and of a kind of mucilage, transparent, and afterwards opaque,

opaque, before they assume the solidity which ought to characterize them.

22. In this gelatinous or mucous state, which the fecula assumes by means of boiling water, it has the faint taste or insipidity of the mucilages, the property of being thickened by the action of the fire, or being diluted and dissolved in water, and of turning sour in the course of time. It particularly acquires the property of being easily digested, and serving for the nourishment of man, with much greater promptitude than it could in its dry, pulverulent, and insoluble form. Accordingly this kind of boiling or solution in hot water, which is manifested and marked by a particular smell which is sufficiently agreeable, is the most general, and, in some measure, the most constant preparation which men employ for converting the fecula into a more pleasant and lighter nutriment, which very quickly recruits their strength, and is speedily converted into their own substance. It is especially under this form that it is given to children, with whom it is sometimes substituted instead of the milk of their mothers, or supplies its place pretty constantly, as we see amongst most civilized nations.

23. The acids with simple radicals, alter the amylaceous fecula more or less powerfully, and comport themselves with it precisely in the same manner as with mucus. When diluted with water they dissolve it, especially with the aid of heat, much more quickly and easily than water

alone does ; they form with it a kind of jelly or mucilage of a perfect transparency : when they are concentrated they decompose it. The sulphuric acid blackens it, forms water and acetous acid by the union of its principles, which it solicits in another order than that in which they were combined, and precipitates carbon from it. With the assistance of fire it disengages carbonated hydrogen gas from it, as it does from gum or sugar. The muriatic acid acts in the same manner upon starch, but much more slowly than the preceding acid. The nitric acid dissolves it by heat without reducing it to coal, disengages nitrous and carbonic acid gas, does not precipitate mucous acid from it, as it does from the gums, but converts the whole amylaceous mass into malic and oxalic acids. The carbonic acid renders the fecula more soluble, and promotes its acescency.

24. The caustic or pure alkalis, dissolve fecula with the help of water, reduce it to a gelatinous state, but do not alter its intimate nature except with difficulty and at a high temperature. The salts which quickly part with oxygen, burn and decompose it. Thus it is destroyed by nitrate of pot-ash when heated with it. It inflames and detonates violently by mere pressure or percussion, with the super-oxygenated muriate of pot-ash, which inflames it.

25. The metallic oxides also burn it, especially those that are little tenacious of their oxygen ; the same is the case with the metallic

solutions

solutions, from which it frequently separates the oxides by mere contact, continued for a longer or shorter space of time, colouring them, as they usually are, according to the different proportions of oxygen which they yield to it.

26. Fecula unites easily in nature, and even by the operations of art, with most of the different immediate materials of vegetables; thus it is found associated in plants with the extracts, the mucus, the sugar, the oils, the colouring matters, and the gluten. Art also effects these factitious associations pretty easily, especially that with the colouring substances; by this means, as I shall show elsewhere, are fabricated the colours so much used for paper, and sometimes even for valuable paintings, which are known by the name of lakes.

27. From all the chemical properties which I have just presented relative to the amylaceous fecula, it may be concluded that this body is a kind of dry and pulverulent mucus, different however from the gummy matter in its affording no mucus acid by the action of the nitric acid, and its not being soluble in cold, but only in boiling water. It announces itself as being a little less carbonated than the latter, though I cannot yet present the proportion of the principles that enter into its composition. It might be said to follow the saccharine matter very nearly, and we shall see hereafter that it appears to be actually capable of forming it by a peculiar alteration of its own substance. As some chemists have announced that the fecula
affords

affords sensible traces of ammonia in its analysis, it should seem, from this circumstance, that the fecula contains azote amongst its primitive principles. However this assertion relative to the production of ammonia in the analysis of starch by fire wants confirmation, and cannot yet be admitted as a demonstrated fact.

E. *Species of Feculas.*

28. THOUGH there is only a single substance that ought to bear the name of fecula or starch; though this substance is exactly of the same nature in all vegetables, when it has been extracted and purified with ease by chemical processes, it is a matter of too great importance to society to be well acquainted with the principal states in which it exists in nature, as is also the art, which is founded upon this knowledge, of applying it to the different uses to which it may be made subservient, for us to omit paying some attention to the species of it which nature presents. It is very evident at first that the distinction of these species can be founded, and their real difference established, only upon the different mixtures which it presents in the vegetables that furnish it, as well as upon the diversity itself of the parts from which it is extracted.

29. Under the first relation, that is to say, under that of the different mixtures, or combinations which distinguish the amylaceous fecula in vegetables that contain it, we may admit

admit six principal states, or six species of fecula, according to the nature of these different substances which are mixed with it. I shall first observe, that it is no where absolutely or intirely pure and insulated, that wherever it is met with, it is alloyed with some foreign substances, and that on this account we are obliged to separate it by water, which takes it up in powder and deposits it, retaining the soluble matters, and leaving separate the gross parenchymas which likewise altered it. The six principal species which I distinguish, by adding to their names adjectives which characterize each foreign matter, are the *glutinous fecula*, the *extractive fecula*, the *mucous fecula*, the *saccharine fecula*, the *oily fecula*, and the *acrid fecula*.

A. The *glutinous fecula* is that which is found naturally united with glutinous matter; it is found in wheat, and, in general, in all the cereal grains, though most of them contain much less gluten than the first. We shall see in the subsequent article by what process the separation of the gluten, which gives it particular properties, is effected.

B. The *extractive fecula* always recognizable by its fawn, yellow, greenish, &c. colour, is especially found in the leguminous seeds, and in the farina which is obtained from them by grinding. It is to an extract that it owes its colour and its harsh, acerb, herbaceous, bitter taste, as well as its more or less pungent smell. The farina of peas, lentiles, French beans, lupines,

pinces, chich-peas, &c. is of this species. There are also found varieties more insupportable and more difficult to be purified in the horse-chestnut, the acorn, &c. It is very difficult to extract it pure, which requires long and abundant washings.

C. The *mucus* fecula, well characterized by its viscous gluey state, exists in many roots, in all the unripe kernels, in the cereal grains in the milky state. Sometimes it is only the transition from the mucous to the feculent state; sometimes it remains in the gluey and mucous form at all the periods of vegetation. The root of the potatoe, *convolvulus patatas*, is the most marked and striking example of it. This fecula is very difficult to be obtained pure.

D. The *saccharine* fecula, or the natural mixture of fecula and sugar, is found in several roots, in some saps, and even in the gramineous feeds when they have germinated. It is one of the most useful associations which nature can present to man, and it is the substance which he seeks with most avidity for his nourishment. Both food and condiment are united in this natural combination. The sugar is very easy to be separated from the fecula, on account of its great solubility in water; and the most simple washing is sufficient for this operation.

E. The *oily* fecula is very frequent in a great number of emulsive feeds, or those which by being bruised, together with water form a milky liquid. When the oil has been separated by expression,

pression, the fecula which remains, besides that it obstinately retains a small quantity of it, as is perceived by the unctuousity of the paste of kernels, is also mixed or charged with a mucous and extractive matter, and even with some ligneous particles which cannot be separated from it except by several successive washings and depositions.

F. The *acrid* fecula, whether it be pungent, like that of the cruciferous and antiscorbutic roots, or caustic and burning, like those of arum, of assarabacca, of briony, &c. or poisonous, like that of manioc, owes this property to a portion of the juice of the plant itself that remains upon its surface, and which, when it is dried, without having been previously washed in a large quantity of water, preserves in it a part of the properties, whether alterative, purgative, or even poisonous, which the intire juice itself possesses. We may deprive it of this taste, and render it very mild and simply nutritious, by merely washing it with pure water, in sufficient abundance not to leave any foreign parts.

30. It must be added to this enunciation of the six species of fecula, distinguished by the foreign matters that are mixed or combined with it by nature, that the fecula is often found associated at the same time with several of these matters, which I have only indicated separately in order to present the mixtures in an orderly arrangement. Thus the fecula of
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the leguminous plants, or the farina of pease, beans, &c. frequently contains one or two extracts, a colouring substance, and a mucous matter. The paste of kernels of different kinds, besides the oil, contains, as I have announced, colouring matter, extract, mucilage, ligneous matter, and sometimes even saccharine substance. It is moreover evident, that these multiplied combinations may greatly vary, according to the different states of modification of the trees or plants which furnish them.

31. Another distinction, no less important to be made between the feculas, is that which relates to the vegetable parts from which they are extracted. It is to this distinction that the series of the species of fecula which are prepared for the purposes of society really appertains. Amongst the feculent and acrid roots are reckoned those of briony, of arum, of manioc, of potatoes, and of orchis; amongst the stalks, those of the palm, which furnishes sago; amongst the seeds of the graminaceous plants, meal, properly so called; amongst the class of vegetables which seem to be intirely composed of it, the nutritive paste of the Lichen Islandicus; finally, we may also enumerate amongst these species the paste of paper. I must say a few words concerning each of these feculas in particular, and even add some details concerning those vegetables, which, though none has hitherto been extracted from them, may afford very useful feculas.

A. The

A. The fecula of briony formerly was prepared for pharmaceutical uses. After this root had been peeled, rasped, and pressed, it was submitted to the press, by which means a turbid and milky juice was extracted, which was filtrated; the fecula which it had precipitated upon the filtre, was washed, and the mass which had remained in the press, was diluted with water: this last washing afforded a fecula more abundant and still finer than that which was deposited by the expressed juice. These two feculas, mixed and washed for the last time with a sufficient quantity of water for it to pass off without taste, were very pure, very tasteless, insipid, or mild; no longer partaking of the acrimony of the root, they may be used like the starch of wheat, from which they differ in no respect. When it was desired to have it purgative, it was not washed and precipitated by means of water; but the expressed juice was suffered to form its deposit without the addition of water. When well washed, on the contrary, it may be employed as food.

B. The root of the arum, that of assarum, and many other acrid tuberous roots of our climates, might be treated like those of briony, and furnish, like this, a white fecula, fine and pure, mild and alimentary, when well washed; but acrid, purgative, and emetic, in a degree the more intense, the larger the quantity of the juice of the plant that should be left in it.

C. The

C. The root of the manioc, *jatropha manioc* of Linnæus, consisting of several large, fleshy, and ovoid tubercles, is employed chiefly in America as food for man, though, like the preceding, it contains a very acrid and intensely poisonous juice, since, according to all the historians of that country, a spoonful is sufficient to poison a man. After the fresh root has been peeled, it is inclosed in a sack of rushes of a very loose texture, which is suspended to a stick placed upon two wooden forks; to the bottom of this sack a heavy vessel is suspended, which, by drawing the sack, presses the rasped root, and receives the juice that flows out of it. When the fecula is well exhausted of its juice, it is exposed to smoke in order to dry it, and when it is well dried it is passed through a sieve. In this state it is termed *cassava*; this is a kind of farina. It is baked into cakes, by spreading it upon hot plates of iron or earth, and turning it upon both sides in order to give it a gold or reddish colour. It is also formed into *couac*, or small grains, resembling sago, by agitating it for several hours in a basin placed over the fire. The expressed juice of the manioc deposits a fecula finer than the preceding; after it has been well washed and dried, it is employed for making confectionary; it is termed *mouffache*. We see here the same results as are obtained with the roots of briony, of arum, and of assarum.

D. The

D. The root of the *solanum tuberosum*, or potatoe, has for several years past been employed for preparing a very fine fecula, a very fine, very white, and very mild starch, which has been called *amidon de santé*, on account of its good properties. After these roots have been peeled, they are rasped, and the pulp is placed upon a close hair-sieve; water is poured upon this pulp and agitated with it, till the liquid no longer carries along with it any white matter. The liquid which passes off deposits a very fine and very mild white powder, which is carefully dried, and becomes brilliant and as it were crystalline by this desiccation. It presents all the properties of pure starch, which it even surpasses in fineness and whiteness, when it is well prepared. A kind of sago is made of it, by drying it whilst moist and constantly agitating it in a vessel over a gentle fire. The water which swims above this fecula has frequently a greenish aspect, which depends upon the extractive part which it has taken from the root. Rasping-mills have been contrived for preparing a large quantity of the fecula of potatoes at a time. It is also formed into a kind of vermicelli, by passing it moistened with a little water through a cylinder perforated with holes at its extremity, and drying the soft small cylinders that are formed by this kind of mould.

E. Salep, which is also called *salab*, *salop*, &c. in different parts of the East, is formed from
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the roots of different species of the orchis, especially the *orchis moria*, which are dried in the sun, either after they have been boiled in water, or, which is the more frequent practice, after they have been merely cleaned and well rubbed with brushes in this liquid. In the latter process, which is greatly preferable to the first, the bulbs when well brushed are dried in a stove which renders them brittle, dry and semi-transparent. The roots dried in the sun are strung in a row upon strings, by means of which they are suspended in the air. This simple preparation enables them to be easily reduced into powder or ground, so that they may afterwards be boiled in water. The salep thus forms a kind of very mild and very nourishing jelly, the analeptic and mollifying power of which was formerly much extolled. The same operation may be performed, and an equally wholesome and useful food prepared with the more or less tuberous roots of all the species of orchis.

F. Sago is a dry fecula, in round and slightly reddish grains, baked or condensed by the action of the fire, which is brought from the Moluccas, especially from Java, and from the Philippine islands. It is extracted from a species of the palm, termed *landan* in the Moluccas, which is the *cycas circinnalis* of Linnæus. The trunk of this tree contains a white and sweet pith, which the inhabitants extract by splitting the tree longitudinally. They bruise this pith, put it into a kind of funnel of bark, placed over a hair sieve, and soak it with a large quantity of water;
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the fecula carried away by the liquid passes through the holes of the sieve, and leaves upon it the fibrous and gross part of the pith. The water, received into a pot, deposits in it a light fecula, which is detached from the medullary texture; when the deposition has been well performed, they pour off the water; and pass the former through perforated plates, which give it the form of spherical grains; these they afterwards dry over the fire in vessels in which they constantly agitate it. These grains of sago swell, soften and become transparent when boiled in water.

G. Farina, or flour, properly so called, that which is obtained from wheat, and differs considerably from that of all the other kinds of gramineous plants, is a dry, friable substance, little sapid, though soft under the finger and upon the tongue, is prepared by merely pounding or grinding the grains of wheat. Though the farina of rye, of barley, of oats, of maize, and of rice, resemble it, in some respects, yet the flour of wheat, *triticum*, a species of plant, which civilized man has selected amongst thousands of others as the best adapted for his nourishment, a vegetable which cultivation has manifestly improved and modified for our wants, differs, however, from them in its property of forming with water a paste considerably ductile and homogeneous, which easily retains the forms which we give it, which rises and becomes divided by a commencement of fermentation, and alone affords good bread, and forms this aliment, so general, so useful, and so well known by almost

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all mankind as their first nourishment. These properties are owing to the mixture of the three substances which constitute it; the amylaceous fecula properly so called, which forms nearly three fifths of it, and is extracted from it by washing the paste, which the water carries away and deposits in a white powder; the glutinous matter, which remains in a viscous and elastic mass after this washing, and of which I shall speak in the subsequent article, constitutes nearly a fifth of the whole weight of the farina; and a saccharine matter which remains dissolved in the water, and is obtained from it by evaporation. It is known that it is more especially from this farina that starch properly so called is extracted. It is also known that the farina of wheat must admit of varieties in the proportion of its three principles, according to a multitude of circumstances of vegetation. It is also proper here to remark that bread which is well made, and which has fermented into leaven, is acid, that its decoction reddens the blue vegetable colours, and that it becomes still more so in the stomach.

H. Several species of lichens, but especially that which grows in such abundance in Iceland, and which on that account is termed *Lichen Islandicus* by Linnæus, is employed for making a very nourishing kind of bread in the Northern countries. From the experiments made by the Academy of Stockholm upon this lichen, it appears that it affords by simple grinding an
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excellent starch. The same also appears to be the case with the *lichen rangiferinus*, on which the rein-deer are supported, and which so easily fattens them. The inhabitants of Iceland prepare from the farina of their lichens a very delicate and much esteemed meal. It is here to be observed, that several species of lichen yield, in some seasons, a kind of saccharine efflorescence upon their leaves, &c.

I. Paper itself is nothing more than a kind of fecula proceeding from the portion of liber still mucous and succulent, with which the cloth had been fabricated, and which, by being torn, macerated, and boiled for a longer or shorter space of time in water, at last affords a feculent mucilage, that is collected, by cooling, into a thin layer sufficiently solid to oppose a certain resistance to its being torn. This is the base of the facts upon which the art of paper-making is founded. This matter comports itself, in its chemical analysis, absolutely like the fecula; it affords pyromucous acid in distillation, and oxalic acid by the nitric acid. It is soluble in hot water, forms a jelly or paste in this operation, and not to speak in this place of the glue, frequently of an animal nature, with which it is covered in order to prevent it from imbibing the ink into its pores, and to render it fit for writing upon, it is evident that this solution of paper in boiling water might

be used as food in cases where pressing necessity might oblige men to have recourse to it.

F. Uses of the Fecula.

32. WHAT I have hitherto observed with respect to the feat, the extraction, the chemical properties, and the different species of amylaceous fecula, must have rendered it evident that this product of vegetation, considered so improperly as a kind of earth by the ancient chemists, is a particular oxide, a natural compound of carbon, hydrogen and oxygen, and perhaps even of a little azote, which has especially the great advantage of serving in an eminent degree for the nourishment of animals. Accordingly, all the parts of plants which contain it are the prey of numerous classes of these animated beings, from man down to the insects, the larvae and the worms which seize upon them, form their abode in them, and destroy them more or less completely with the different instruments of manducation with which nature has provided them.

33. It is from the fecula that man derives an aliment, the most abundant, the most nourishing, and the most easy to be preserved. Whilst immense tribes of animals devour this substance pure, and such as nature presents it to them, man knows how to give it a thousand dif-

different forms, from the most simple baking or boiling, to that so highly perfected preparation known amongst the inhabitants of the temperate zones by the name of *bread*; from the cassava of the Americans to those confectionaries, so delicate, so light, so sweet and pleasant to the taste, which are made in some parts of Europe, especially in France, in Italy, and in Germany. This primitive aliment admits of all combinations with the oils, butter, milk, cheese, eggs, sugar, aromatic substances, the juices of fruits, the juices of flesh; its natural mildness and insipidity render it the appropriate recipient of a multitude of condiments.

34. Endowed with this knowledge of the eminently nourishing property of the amylaceous fecula, men at once enlightened and philanthropic, (for these two qualities are rarely divided,) may render essential services to society by greatly multiplying the sources of alimentary matter, and showing that a very numerous series of vegetable substances, which are not generally employed for this purpose, may be very easily and successfully appropriated to it. It is especially in times of scarcity, after the unfavourable seasons which too frequently deprive the people of their hopes of obtaining sufficient provision for their subsistence, that all the aid which chemistry can afford ought to be called in to the relief of nations. A satisfactory idea of the important services which

it is able to afford may be derived from reading several modern chemical works, especially those of Citizen Parmentier, who has deserved so well of his country and of humanity in general, by occupying himself with a perseverance which philanthropy alone could instigate, in the investigation of all the alimentary resources which nations may derive from the culture of the potatoe, of Turkey-wheat, or Maize, and of many other vegetable substances that have been too much neglected, notwithstanding all the advantages which they promise.

35. A multitude of other secondary utilities accompany this first utility of the feculas, and render them one of the most valuable substances which man can derive from vegetables. Medicine has borrowed from them not only a variety of foods well appropriated to a multitude of particular circumstances of diseases, but also mollifying, inkrassant, agglutinating remedies, preparations adapted for allaying irritation and pain. It is sufficiently known what advantage the art of healing derives from different farina, from the fecula of the potatoe, of sago, of salep, &c. It is true that the most of these preparations have been too much extolled; and that by endeavouring to attribute to them almost supernatural and miraculous virtues, a part of the confidence which they merit has been destroyed. But enlightened physicians, equally remote from ridiculous enthusiasm and dangerous

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rous indifference, employ them with the greatest advantage.

36. Finally, the arts perpetually employ the amylaceous fecula for a multitude of uses or render them of important service. By ebullition in water, they are made into glues, or pastes, which serve to keep together a number of surfaces of light bodies applied the one over the other, and to effect between them an approximation and cohesion necessary in a multitude of circumstances. They are also employed as drying substances, especially for the hair: for this purpose what is called *hair-powder* is prepared from them; a kind of custom, perhaps very ridiculous, of several modern nations, in which they imitate, without being aware of it, the nations whom they term barbarous, and by which, a circumstance of great importance, they entirely lavish away a very considerable portion of the subsistence of a great number of families: it is proper, therefore, to employ for this purpose such feculas as are not used as food.

ARTICLE IX.

Of the sixth of the immediate Materials of Vegetables ; of the Gluten.

A. Situation.

1. THOUGH it is especially in the farina of wheat that we find the glutinous substance, or the matter discovered by Beccari and Kesselmeyer, and named by them *glutinous vegeto-animal* matter ; though it can only be extracted from the farina of this plant, it is allowed by all chemists that the cereal grains contain a certain quantity of it, and that it cannot be separated from them, because it either exists in them in too little abundance, or too much disseminated in the amilaceous fecula or starch.

2. Rouelle the younger, who had especially examined and compared it with animal matters, affirms that he had found it in the coloured fecula, and especially in that which was termed *the green fecula of plants*. But the expression of fecula, applied indiscriminately to the juices of the plants and to the starch, having led chemists to consider the latter as a part of the remains of solid vegetable substances, there is reason to believe that it was merely from analogy, and also from some equivocal properties that Rouelle imagined that the green matter contained the glutinous substance. At least the experiments that have been made since his time, such as I have several times repeated upon these

these coloured feculas, have not afforded me the confirmation of this assertion, and no fact has really proved the glutinous matter to be one of the principles of this latter fecula.

3. There is a more exact and more positive observation relative to the presence of this glutinous matter in the vegetable texture which forms linen and paper. Citizen Desmarets has observed in the paper manufactories, after the heating or rotting of the rags, and when this substance is melted and softened in water, that thick, solid, insoluble flakes of real gluten are separated. An analogous phenomenon is observed in the work of laundresses. The alkaline leys and the water charged with soap which they employ for washing linen, especially finer linen, take from it a principle which separates, in sufficient abundance, in the drains into which they throw these liquids to choke them up, to stop up the grates which intercept their continuity, and to prevent these liquids from running. There are also found upon these grates, flakes, or masses almost solid, rather soft and ductile, manifestly precipitated from the leys, and separated from the texture of the linen itself. By this means also this texture is gradually worn, rendered thinner and made to lose its weight and form.

4. Lastly, Citizen Deyeux has thought he has discovered the existence of the glutinous substance, in the saps of the yoke-celm and the birch; he has even thought that this
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substance is dissolved in them by the mediation of the acetous acid, and that it was obtained precipitated from these liquors in insoluble and solid flakes, only by the evaporation or the dissipation of this acid. I must, however, observe, that Citizen Vauquelin, who has examined the same liquids, did not find them to contain the glutinous principle, but only extract. It is true that this may depend upon the difference of the saps which those two chemists have examined, and that of the trees which afforded them.

5. It must be concluded, from what I have just set forth respecting the almost exclusive seat of the glutinous principle in the farina of wheat, that this substance is, perhaps, of all the immediate materials of vegetables, that which is the most rarely found in plants, or at least that which is extracted with the most difficulty, which is either less abundant than many others, or more intimately mixed or combined with other materials, so that it cannot be separated without the greatest difficulty.

B. *Extraction.*

6. The glutinous principle is extracted by processes similar to those that have already been described in several of the preceding articles, and which, being dependant upon mechanical operations, cannot change its nature or alter its composition. The manner in which this principle is
extracted

extracted from the farina of wheat, is one of the most simple and ingenious, and at the same time the most exact. It is by separating the starch from this farina that we separate the glutinous principle.

7. Scarcely has a little water been thrown upon the farina, which, as I have already observed, alone presents this remarkable character, when its particles approach, adhere, and stick to each other, forming a mild, gluey, homogeneous paste, easy to be kneaded, tenacious, elastic, which may be elongated, flattened, drawn in every direction, without breaking or cracking. This paste, washed in a small stream of water, and gently kneaded or worked, immediately by the hand of the operator, or well pressed in a bag of linen, equally exposed to a stream of water, suffers this liquid to carry away the amylaceous fecula in the form of a white powder, which renders it milky. In proportion as the water carries away this starch, the paste assumes a more grey colour, less brilliant as it were, semi-transparent, and also of a softer consistence, but at the same time more tenacious, more viscid, more gluey, and more elastic. In this manner we continue to knead the paste of the wheat, till the water passes off clear, and without any feculent powder. Thus the farina is separated in three substances, the starch, which is precipitated in a white powder at the bottom of the water, another which remains dissolved in the liquid, and the third which remains soft, cohesive, and elastic.

8. It is evident that this glutinous matter, which was in the state of powder in the farina, assumes at the very instant in which the paste is formed by the addition of water, the gluey and elastic state which it did not before possess; that the starch which then adheres to it but feebly, and which seems to have covered only the exterior fibrous fasciæ, is detached from it by mere contact of the water, and that the water contributes to its pasty and ductile state. It is no less certain, that it is to this property of the pulverulent particles of the gluten to become elastic by the addition of water, that the farina of wheat owes that of forming of a paste, and that it is in proportion to its quantity, that the panification, more or less sensible in this farina, varies according to the state of maturity, the nature of the corn, and that of the soil, the season, and all the circumstances relative to the vegetation of this important plant.

9. It is very remarkable, that the gluten seems to disappear, or at least can no more be separated or extracted from the farina of wheat; if instead of adding at first little water, and forming a thick, ductile dough, which is afterwards washed with a small stream of water, we suddenly steep it in a large quantity of this liquid, and reduce it to paste; we then, indeed, give this liquid, by means of heat, the property of forming a viscid, thick, very gluey, and opaque mass, as is done in the preparation of paste; but we deprive it of that of separating and insulating the glutinous matter from the starch.

starch. It seems that by this dilution with a large quantity of water, we entirely insulate the particles of this body, disperse them among that of the fecula, and prevent them from approaching and adhering together, as they do in the simple state of dough. Hence it happens, that in these pastes of the flour of wheat, with which wafers, vermicelli, lozenges, &c. are prepared, we can no longer, according to the experiments of Macquer and Pelletier, find again the gluten, and obtain it in the same manner as in the thick ductile pastes, washed by means of a small stream of water: thus the quantity of this liquid and the manner in which it is employed, has a singular influence upon the extraction of the gluten.

10. When the solid and ductile dough of the flour of wheat is left to itself, at a temperature of at least fifteen degrees, instead of being washed with a small quantity of water, in order immediately to extract the gluten from it, it quickly undergoes an intestine motion, which is not remarked in starch equally impregnated with water; it becomes inflated and filled with cavities, produced by the disengagement of an elastic fluid, and proceeds quickly towards acescency. This motion is accelerated by adding to the paste a portion of a ferment taken from dough that has already risen, or from the yeast of beer, as is practised in the fabrication of bread. If the dough be baked before it has undergone this motion, we obtain no real light bread, filled with cavities, and
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easy of digestion; but a kind of thick, heavy cake, much more difficult to be digested. As starch alone does not present this phenomenon, it has been thought that the presence of the glutinous matter was the cause of it. Accordingly, by adding glutinous matter artificially to a pure amylaceous fecula, which contains none of it, whether it proceed from the farina of wheat, or have been extracted from any other vegetable matter, we form a dough which rises and affords real bread by baking. It is so true, that the gluten contributes to this panary fermentation, and is the real source of it, that well made dough scarcely furnishes any more of it after having fermented, and affords none at all after the baking of the bread, though this gives out, in its analysis by fire, a proportion of ammonia sufficiently considerable to distinguish its products very well from those of pure fecula.

11. It is to the same absence, or at least to the small quantity of the glutinous matter contained in the farina of rye, of barley, of oats, and especially of maize, of rice, of millet, and of all the other cereal grains, that we must attribute the impossibility of making good bread, well risen, light and porous, with these farinas. Still less can we prepare any other than crude, heavy, insipid cakes, with the farina, from powders of leguminous seeds, of the feculent roots, and of all the amylaceous vegetable powders deprived of the glutinous principle. It would be very interesting

interesting to know, whether this principle of the gluten exists in the farina of the lichens, with which pretty good bread is made. The only fact well ascertained respecting these different farinas, so different from that of wheat, is, that none of them forms like the latter a real dough, cohesive and ductile, nor affords a similar quantity of glutinous matter, when washed with water, added by degrees. We hardly find any traces of it in the farinas of rye and of barley, which, however, approach the nearest to that of wheat in their property of forming dough, by the tenacity and cohesion which they acquire by kneading. We find no vestige of it in the farina of rice, of maize, of millet, &c. We easily judge of the small proportion of the gluten contained in these different species of farina, by the nature of the dough, which is obtained by kneading them. The less they contain of it, the more the dough which they yield is dry, brittle, not ductile, difficult to be kneaded, the more it cracks, dries, and becomes covered at its surface with a brittle crust; the less they also rise when kept at a temperature of fifteen degrees.

12. The property of forming a good dough is so closely connected with the presence of the gluten in the farina of wheat, that this farina itself presents variations in this property relative to the quantity of this matter which it contains. In fact we may judge of the goodness of this farina, of the maturity and of the
good

good qualities of the corn which furnishes it, either by the manner in which it comports itself in kneading, or which is a much more certain method than the first, by the proportion of glutinous matter that is extracted from it by the process which I have described. Chemists have already found remarkable differences between the various kinds of farina of wheat, according to their qualities, the nature of the corn, that of the soil in which it has been reared, that of the year, and the seasons in which it has vegetated; and it were much to be wished that their researches relative to this subject might be further prosecuted, as they may afford a sure means of distinguishing the qualities of the farina, and determining their nutritive properties. Beccari has already observed, that the proportion of the gluten varies in the farina of wheat from a fifth to a third. In proportion as the farina of wheat is altered and deteriorated, which happens, as it is known, when it is kept too much compressed, without being stirred and aired, in hot and moist repositories; in proportion as it becomes heated, as it assumes odour, in a word as it ferments, its property of affording gluten is at the same time diminished; and when it is very much altered, it affords only some detached flakes, which can no longer be made to cohere, of which we can no longer form a single mass, a ductile whole. Accordingly this very easy and simple operation of extracting the gluten of the farina, becomes

becomes a rigorous and exact test for ascertaining the goodness, the quality, and the good or bad state of this useful matter.

C. Physical Properties.

13. THE glutinous principle, when properly prepared, resembles no other vegetable matter; it is soft, tenacious, adhesive to the touch when the fingers are dry, elastic, susceptible of elongation when it is drawn, and returning to its former state when left at liberty; of a greyish colour, of a faint taste, and of a smell nearly resembling that of the human sperm, or that of scraped bones when violently rubbed.

14. The elastic property of the gluten is that which characterizes this substance in the most singular manner. When lengthened with the hand, it becomes flat and thin as it is stretched; it assumes the appearance of a white, brilliant and silky membrane, like the aponeuroses, or the membranes of animal bodies. It then exhibits a fibrous texture, the filaments of which seem to be interwoven with and crossing each other.

15. Its gluey property and the strong adhesion which it contracts with many bodies, is also one of its most marked characters. When we attempt to detach it from any substance upon which it is deposited, it is extended into filaments detached from each other, and resembling the texture of felt: its mere aspect is sufficient to show its resemblance with the animal substances

stances, with which it is found to have a striking analogy. It becomes brittle by desiccation, and then it resembles glue.

16. The glutinous matter assumes a yellow and brown colour, and seems to become covered with a layer of oil, by exposure to the light. When it is exposed to a gentle fire, it rises, swells, separates and becomes filled with cavities or bubbles; at last it dries, without assuming much colour, and preserving the grey cast which distinguishes it: it becomes brittle and unalterable by the air, like glue, and all its ductility and elasticity disappear. When placed upon a burning coal, this dry gluten becomes agitated like an animal fibre, fuses, kindles, and burns, swelling at the same time with a fetid odour. If it be distilled dry in a retort, it furnishes little ammoniacal water, a large quantity of brown, fetid, and thick oil, much solid and crystallized carbonate of ammonia, a little prussic acid, likewise in the ammoniacal state, with oily carbonated hydrogen gas; and there is left a coal difficult to be incinerated, and in pretty considerable quantity, since it amounts to nearly one fifth of the weight of the glutinous matter. These products have all the disagreeable smell of animal substances submitted to distillation; so that they might be confounded together, and it is very apparent why the first authors termed this substance the *vegeto-animal matter*.

17. Exposed to the air, the gluten dries when the weather is very dry and the substance

stance in small layers: when the air is moist, and the gluten in a mass, it changes, and putrefies, swelling at the same time like animal matter. When it is not intirely deprived of starch, when it retains any between its particles, the latter passing into the acid fermentation, and retarding the putrefaction of the glutinous matter, reduces it to a state very near resembling that of cheese. Roulle the younger, in his course of lectures, exhibited glutinous matter thus prepared, and preserved by means of salt, in a kind of cheese similar to that of Gruyere, or of Holland, in its texture, its smell, and its taste.

18. Water does not dissolve gluten, but even prevents its adhesion to the bodies with which it has the greatest disposition to cohere. The glutinous matter is preserved for some time under water, in order to prevent the drying of its surface, and its alteration by the air. When we boil water upon this substance, it contracts, and becomes more solid than it was before: so far from being divided and dissolved, it soon loses its viscosity and extensibility. When we compare this action of the water with that which it exerts upon the molecules of the pulverulent gluten of the farina, which it reduces in some measure to a ductile state, we see that this matter, in the latter state, is saturated with water, and cannot imbibe any more.

19. All the acids much diluted with water, even those that are the most feeble in their

nature, such as the acetous acid, soften the glutinous matter, dissolve it, and suffer it afterwards to be precipitated by the alkalis, but in the form of a matter that has lost its ductility, and which Macquer imagined to approach to the nature of the mucilages. When the acids are concentrated they act in a very different manner upon this body. The sulphuric acid gives it a violet colour, blackens it, carbonates it, dis-hydrogenates it, so far as to disengage from it a very inflammable gas, and to convert it partly into acetous acid, and partly into ammonia. The nitric acid disengages from it in the cold, azotic gas, as from animal substances, turns it yellow, converts it in part into malic and oxalic acids, and into yellowish, oily, or fatty flakes: this presents another analogy with the animal substances. The muriatic acid acts upon it as slowly as the sulphuric acid does quickly, and after remaining long in contact with it, the fluid contains muriate of ammonia.

20. The alkalis when pure, and a little concentrated, dissolve the gluten with the aid of heat; we may precipitate it from them by the acids, but altered, and no longer elastic. When highly concentrated, they convert it into a kind of soap, giving it the oily character, and disengaging from it ammonia, of which they occasion the instantaneous formation, when they are triturated with the gluten. The salts, if we except the super-oxygenated muriate of pot-ash,

which, by mere pressure, burns and inflames it with detonation, have no other action upon it than to preserve and to defend it against its septic alteration. The metallic oxides, which it reduces more or less, decompose it by burning, as do also the metallic solutions.

21. All these properties show that the gluten is a substance very different from the other immediate materials of vegetables, that it approaches very much to the nature of the animal substances, that it comports itself as they do with fire, air, the acids, and the alkalis, especially that it yields ammonia and oil, no less abundantly than several of those substances; and that besides the hydrogen, the carbon, and the oxygen which it contains, like all the other vegetable matters, it contains amongst its elements azote, which singularly changes its properties, and gives it all those by which it approaches to the animal compounds.

E. *Species.*

22. NOTWITHSTANDING all that chemists have advanced for forty years past concerning the glutinous matter, which was discovered nearly at that period, and concerning its existence in different vegetables, and in different parts of plants, it is very certain that it is only from the farina of wheat that it has been extracted in the ductile, elastic, extensible, and soft form which characterizes it. It seems even

in this respect that this plant, the general aliment of so great a part of mankind, differs remarkably from all other known vegetables, as it is the only one that affords this singular product.

23. In order, however, to follow what the most able chemists have announced or suspected concerning the presence of the glutinous matter in several other vegetables, I shall enumerate as species,

A. The elastic gluten of the farina of wheat.

B. The filamentous or flakey gluten of other cereal farinas, especially that of which some traces are found in barley in rye, and in oats.

C. The glutinous matter of the green fecula of plants, announced by Rouelle the younger, but not exactly proved; that of linen.

D. That which Citizen Joffe asserts he has extracted from opium, by treating it with water in the same manner as the dough of flour.

E. The portion of gluten indicated in the sweet or acid saps by Citizen Deyeux.

F. Bird-lime, prepared, as is well known with the fruits of the mistletoe, with the tender bark of the elm and of several other trees macerated in water. Though this substance has not yet been examined with sufficient attention, it presents many properties analogous to those of the glutinous substance.

24. I shall

24. I shall add to this enumeration, that there is prepared in pharmacy, under the very improper and erroneous name of paste of mallows, a sort of tenacious, ductile, elastic, and as it were glutinous matter, with a solution of gum thickened with sugar, and mixed with white of egg well beaten up; in fact, this mixture is soluble in water, though with difficulty. Finally, I shall observe, that the particular species of vegetable matter known by the name of caoutchouc, or elastic gum, has many of the characters of the glutinous matter, as I shall show hereafter.

F. *Uses.*

25. It has been thought, from the comparison of the gluten with the animal matters, that this substance had more especially the nutritive and restorative property, that it formed the base of the nourishment of men who live particularly upon bread, and that in this consisted the advantage of wheat over the other alimentary plants. However, the gluten alone, when presented to animals, is either rejected by them, or it very soon disgusts them; and it appears to be necessary that it should be attenuated by fermentation and combined with the amylaceous matter, in order properly to answer this important purpose.

26. The glutinous matter is sometimes used for glueing together fragments of porcelain, glafs,

glafs, and pottery: it was employed for this purpose in France long before it had been extracted and examined chemically. It is separated in the laboratories of chemistry for the purpose of examining its properties and characters. It is not yet known either to what part of the feed it belongs in wheat, or what functions it performs in germination, fructification, or vegetation.

ARTICLE X.

Of the Seventh of the immediate Materials of Vegetables; of the Extract or Extractive Matter.

A. Situation.

1. **THOUGH** the name of extract was at first applied in pharmacy to all the substances that were separated or extracted from vegetables; though this expression, which is purely pharmacological, has been particularly appropriated to designate medicinal products, as the vegetable analysis has long been exclusively applied to the preparation of medicines, yet the first pharmaceutical chemists of more or less note, who have occupied themselves with deducing chemical results from pharmaceutical operations, have distinguished some principal kinds of
extract

extracts amongst those which they prepared for medicinal uses.

2. Thus Rouelle has distinguished three principal kinds of extracts, the mucous, the saponaceous, and the resinous extracts. But it is evident from the exposition of the characteristic properties which he attributed to each of these extracts, that they are real mixtures of several of the materials of vegetables which are the causes of these differences, and that though this distinction was of utility for discriminating and separating the extracts pharmaceutically prepared, it was, nevertheless, adapted only to produce a real confusion of ideas under the chemical point of view.

3. Independent of this distinction, which is more luminous for pharmacy than for chemistry, we ought to conceive that the extractive is a particular matter, neither mucous, nor saponaceous, nor resinous, but merely mixed with one or other of these substances, either by the work of Nature herself, or by the processes which are employed for obtaining it; that it may be separated from these bodies with more or less difficulty by chemical means; and that when thus purified, it possesses properties very characteristic, and very different from all the other immediate materials of plants. One of its most marked characters is, that it is found united or mixed with several different substances, and never exists pure in vegetables.

4. The

4. The extract, considered under this point of view, exists in many parts of plants, and its seat seems to be every where or in some respect indifferent: however, it is particularly found in the green or brown coloured solid parts. Thus the fibrous roots, the trunks and the stalks, the barks, the leaves, the fruits afford it in greater or less abundance: and on this account it has been proposed to make extracts from all plants, and from all their parts, especially in a medicinal point of view; and in fact, with the intention of causing the virtues of the vegetables to pass into, to be preserved and even concentrated in this preparation, which was termed extract, only because it was considered as a kind of epitome of the plants themselves.

B. *Extraction:*

5. As the extract is a matter soluble in water when it is pure and without alteration, it exists naturally dissolved in the juice or the sap of plants, so that it is sufficient to evaporate these liquids with a gentle heat, and till they assume the solid form, in order to reduce them into extracts; in this state they are sometimes termed inspissated juices, such as opium, aloes, the juice of acacia, that of the hypocyfis, of flos, the cachou, the extract of borage, and a number of other juices inspissated by the nature of
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of the climate and the sun, or by the artificial heat of stoves, ovens, &c.

6. Frequently the extractive matter, inspissated by the progress of vegetation itself, is found in plants in a solid state. It is more especially in the roots, the wood, the barks, the ligneous and dry leaves, that the extract exists in this state. In these cases, chemists have applied cold or hot water to these vegetable substances, and continued this application, till the liquid passed off without colour or taste. This water, when once charged with extractive matter, is evaporated by a gentle heat till it leaves a dry matter, which is the extract.

7. The extracts that are prepared in pharmacy receive different modifications from the artist, accordingly as the different mixtures which they contain are more or less susceptible of being altered, or of remaining without alteration; for these preparations, made in order to be preserved, ought to be put into a condition not to be decomposed spontaneously. On this account, those which are mucous or fermentiscible are more strongly inspissated or evaporated than those that are bitter and more or less resinous. Hence the different forms and conditions which are given to these preparations; some are soft and like honey; others thick, hard, and dry as the cachou, the juice of liquorice; others in thin, dry, and brittle scales, as their solution has been evaporated upon plates by the heat of a stove: hence the expressions of *rob*, *sapa*; *defrutum*,

defrutum, *essential salts* of Legaraie, which all have only relative, and often erroneous values. It is even useful here to remark, that the greater number of the pharmaceutical extracts are more or less altered, burned, or reduced to coal, by the kind of evaporation itself, violent and long continued, which they are made to undergo; and that those which have been evaporated slowly, have experienced from the atmospherical oxygen, another kind of alteration of which I shall soon speak.

C. *Physical Properties.*

8. THE pure extract is a solid, lamellated, and transparent body, when its solution has been evaporated in thin layers, or granulated, and in opaque masses when its solution has been treated in large quantity by strong evaporation, of a brown, more or less red or deep colour, of a taste almost always more or less sensibly bitter, or acrid, or acerb, and always acid.

9. It is so rare for the extractive matter to be insulated in the common extracts, that the properties which I have just indicated in it are susceptible of a multitude of modifications or variations which prevent their characters being described in an unequivocal manner. However, in seeking those characters which have appeared to me to belong in a special manner to the extractive matter, I have found that its assuming the brown colour, and its property of absorbing oxygen

gen which renders it insoluble, were those which seemed to belong to it exclusively ; that afterwards its taste, its consistence, its more or less considerable alterability were modified in it in a very various manner, according to the different quantity and nature of the matters that were naturally combined with it.

D. Chemical Properties.

10. THE extract is not in the same predicament with the most of the other immediate materials of vegetables ; but it has so long been confounded with some of them ; and mixtures, or combinations of several of these bodies have so long been taken for it, that its chemical properties have not been easily determined, and it is impossible for me to set them forth in the same order, or with the same method as that which I have hitherto followed for the other materials. I have, however, been the first who have endeavoured to diffuse some light over this part of the vegetable analysis, which has hitherto been so obscure and so much neglected, as may be seen in my Examination of the Cinchona of St. Domingo, inserted in the Annals of Chemistry. Since that time, Citizen Vauquelin has resumed this useful inquiry, and carried it much further. In order to afford an idea of the manner in which he has succeeded in determining the chemical nature of the extract, I shall here follow him in the series of observations
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and experiments which have guided him in this inquiry, pointing out what relations subsist between his labours and that which I had described at first in the work already mentioned.

11. It was by examining the sap of trees that this chemist was conducted to the knowledge of the extractive matter. By considering this principle dissolved in the water of vegetation, he remarks that this liquid, which is colourless at the moment when it comes from its canals, assumes a more or less brown cast by exposure to the air; that the expressed juices of plants also become brown or yellow by the contact of the air and the light; that during their evaporation there is formed at their surface a brown or reddish pellicle which breaks into flakes, that similar brown flakes present themselves in the midst of these liquids, that this phenomenon taking place equally in the preparation of pharmaceutical extracts, the flakes in question are confusedly mixed in them with the dried extract, and that when we dissolve this in water there always remains a portion of brown or blackish matter which does not dissolve; that the longer the evaporation is continued, the more points of contact there are between the air and the extractive liquor, and the more insoluble matter is formed; so that by continuing the successive solutions and evaporations of the extract, it cannot be doubted that we may at last render the whole of this body flaky and insoluble. These first facts intirely agree with what I
have

have said concerning the product of the decoctions of Cinchona of St. Domingo, and of the nature of the extract in general, the principal character of which consists, according to me, in its absorption of oxygen and the insolubility consequent thereupon.

12. The solutions of all the pharmaceutical extracts redden the tincture of turnsole. Every solution of extract prepared by the evaporation of the juice of a plant yields, by some drops of ammonia, a precipitate of a more or less deep brown colour, formed of lime and the extractive part become insoluble. The concentrated sulphuric acid thrown upon an extract, disengages from it a very penetrating acid vapour, and we extract from it weak acetous acid, by distilling the mixture of one part of extract with half a part of sulphuric acid diluted with four parts of water. Thus the extracts contain free acetous acid, which renders their taste sour, which causes them to redden turnsole, and combined acetous acid, which the sulphuric acid disengages from them in much greater abundance. When we mix quick-lime in powder with an extract steeped in a little water, a pungent vapour of ammonia rises, which may be obtained from it by distillation. If, after having distilled an extract with sulphuric acid, in order to separate the acetous acid from it, we treat the residuum with alcohol, which dissolves the extract, we find in the residuum
sulphate

fulphate of pot-ash, fulphate of lime, and fulphate of ammonia.

13. It is evident, from the facts, that besides the mucilage, the saccharine substance, the gelatin, the different vegetable acids, the resin, which are so frequently mixed with the extractive matter in the pharmaceutical extracts, they constantly contain acetous acid, acetites of pot-ash, of lime, and of ammonia. It is also known that they frequently contain fulphate of pot-ash, muriate of pot-ash, and fulphate of lime, the existence and proportion of which may be determined by examining them before treating them with the sulphuric acid, and comparing the proportion of these saline products with that which they furnish after the addition of this foreign acid. To these must also be added the nitrate of pot-ash, which is found so abundantly and so frequently in the juices of plants and in their extracts. It is true that this appears to proceed from the soil itself in which they are rooted.

14. These first facts still belong only to the matters which pretty constantly accompany the extracts, and are not especially characteristic of this principle. However, by calling to recollection that those which I have already attributed to it, are its assuming a brown colour by the contact of the air, its precipitation and separation from water, in pellicles, or in insoluble coloured flakes, by the absorption of oxygen, and the precipitation of the juices which

which hold them in solution by the addition of ammonia; it will appear, that the following facts, added to the former by Citizen Vauquelin, may enable us well to distinguish the extractive, and to determine its particular nature with greater accuracy than has hitherto been done.

15. When we pour into a solution of any extract, sulphate of alumine of which the excess of acid has been saturated, and boil this mixture for some time, there is formed in the liquid a very abundant flaky precipitate, which is composed of alumine and of vegetable matter become insoluble in water; the solution of extract has thereby lost all its colour. Almost all the metallic salts produce the same effect: the solution of tin especially forms in that of the extract a very abundant flaky brown precipitate, composed of oxide of tin and of extractive matter, become insoluble. The oxygenated muriatic acid, poured into a solution of extract, forms in it immediately a precipitate of a deep yellow colour, and the liquor has afterwards only a light citron colour, retaining ordinary muriatic acid.

16. When we impregnate cotton or thread, with a solution of alum, and afterwards steep them in a solution of extract, which is then boiled for some time, these white bodies become strongly tinged with a yellowish-brown colour, and are charged with the greater part of the extract, which deposits itself upon their surface, and more or less completely destroy the colour of
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the solution, which we may intirely exhaust of extract by repeating or urging this process. We may succeed still better in totally separating the water and precipitating the colouring matter of the extract in a solid form upon the cloths, by soaking wool, cotton, or thread, for some time in oxygenated muriatic acid, and afterwards immersing them in a solution of extract: the oxygen abandons the acid, seizes the extract, takes it away from the water, and precipitates it upon the cloth, which also exerts a particular attraction upon it.

17. All the extracts, whatever they may be, when subjected to distillation, yield an acid product, in part saturated with ammonia, which contains much more of the latter body than is separated by means of lime or the alkalis. Thus the extract, besides the portion of ammonia that exists ready formed in it, contains also the materials of this alkali, which unite by the action of the fire. When solutions of extracts in water are left alone, the extractive is spontaneously decomposed in them in the course of time; the liquors become turbid, deposit abundant mucous flakes, become covered with different kinds of moulds, diffuse various odours, yield ammonia, and leave at last for fixed products of this putrefaction, carbonates of pot-ash and of lime.

18. From a comparison of all these facts we may deduce the following results:

a. The

a. The pharmaceutical extracts are complex substances, composed of very heterogeneous matters, some of which are pretty constant, and the others accidental, dependent frequently upon the nature of the soil in which the vegetables have been reared.

b. The substances which constantly accompany the extractive matter in the pharmaceutical extracts are free acetic acid, the acetates of potash, of lime, and of ammonia. Those which are accidental in them vary in such a manner according to a multitude of different circumstances, that it is impossible to give a statement of them; all the immediate materials of plants that are soluble in water belong to this order of accidental bodies in the extracts, and may be found in them one or more at a time: it was according to these that Rouelle had made his three classes of extracts, but they are very incomplete, insufficient, and inaccurate.

c. The extract, considered separately from all the substances foreign to its nature, whether constant or accidental, is a substance very different from all the other immediate materials of vegetables; it is characterized by its attraction for oxygen, the manner in which it absorbs it from the air, from the oxygenated muriatic acid, from the metallic oxides, by the insolubility which it acquires by combining with it, by the brown colour which it assumes in proportion as it unites with it, by its union with alumina, with the metallic oxides,

and by its adhesion to cloths by the aid of these mordants, by the separation of the water, effected by the acetite of lime, which is constantly mixed with it, and of the ammonia which is added to it; a separation, which is owing to the double elective attraction of the lime for the extractive matter, with which it is precipitated in an insoluble state, and of the ammonia with the acetic acid.

d. The extractive matter is a kind of oxide with a triple radical, or a compound of carbon, of hydrogen, of azote, and of oxygen, which is not saturated with the last of those principles, but can absorb much more than it contains. It approaches very nearly in its properties to the matter which dyers term *colour*, or *colouring matter*, from which it differs only in the proportion of its primitive principles.

e. The property which the purest extracts possess of attracting the humidity of the atmosphere, and of becoming soft when exposed to it, does not belong to the extracts, but only to the acetite of pot-ash which they contain, and we might even determine by their deliquescence the proportion of this salt which is contained in them. There is reason to believe, that the virtues admitted by physicians in the extracts, are owing only to the acetites which are constantly combined with them, and depend very little upon the extractive matter, properly so called.

19. It is not, however, to be inferred from all these facts, that the nature of the extract, supposing it deprived of all the different matters which it contains, is perfectly identical in all vegetables. On the contrary, it is probable that the proportions of these primitive principles vary a little; but that it is not to this primitive variation of principle that we are to ascribe the very striking difference of the virtues which physicians have observed in opium, the extract of cinchona, that of the wild cucumber, of belladonna, of hemlock, of stramonium, substances so different from one another, but that it is rather to some particular matters added, in each of these bodies, to the extractive, properly so called, that their different modes of acting ought to be attributed.

E. *Species.*

20. It must appear, from what has been observed in the preceding numbers (8 to 19,) that the number of the species of extracts may be very considerable, if we should wish to establish between them distinctions founded upon their individual properties. It would then be necessary to admit as many of them as there are different plants capable of furnishing them. According to each particular matter added to the extractive, it would then be necessary singularly to multiply this classification of the

F f 2
extracts;

extracts ; on the other hand, if we were to consider the extractive matter, properly so called, abstractedly from all the substances that may be added to it, we should then not be in possession of a sufficient stock of knowledge to distinguish with precision the real difference which separates them the one from the other.

21. By holding a sort of middle course between the two limits which the science cannot yet attain, we may continue to employ, but only for pharmaceutical uses, the distinction admitted by Rouelle, namely :

A. *Mucous* inspissated juices or extracts, amongst which are to be ranked the rob of currants, the juice of liquorice, the extract of juniper.

B. *Saponaceous* inspissated juices or extracts, to which are to be referred the juice or the extract of borage, the juice of the acacia, that of hypocistis, of sloes, cachou, and the extract of Peruvian bark.

C. *Extracto-resinous* inspissated juices or extracts, which present amongst their most remarkable species, opium, a very complicated juice, containing, with the extractive matter, an oil and a viscid resin, a mucilage, a gluten, and a salt ; aloes, improperly ranked amongst the gum resins, the elaterium, or juice of the wild cucumber ; and the extract of rhubarb.

22. We are still far too much in want of experiments upon the pharmaceutical extracts to be able to class even conveniently, though still
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with little accuracy, under one or other of these three divisions, the most of those that are prepared and employed in medicine; such as the extracts of gentian, of water-trefoil, of elecampane, hemlock, of belladonna, of pulsatilla, of chervil, of fumitory, of patience, of centaury, of succory, of tormentilla, of saffron. I have here mentioned only the principal and the most commonly employed of these preparations, as the dispensatories contain a number of others equally unknown with respect to their classification.

B. *Uses.*

23. A MUCH greater use was formerly made of extracts in medicine: at present, twenty species at most are employed in pharmacy, including those which are prepared in the large way in commerce. We have seen that for the greater part, excepting those that are acrid, narcotic, poisonous, or violently astringent and febrifuge, their principal virtues, which are aperient, dissolvent, and purgative, may be attributed to the acetite of pot-ash which they contain.

24. We may add to this medicinal use, regarded hitherto as the only one in all the works on chemistry, that there is another which is much more frequent, and much more important for society, namely, that which is made of the extracts in dyeing. All those substances which dyers call colours of roots, or even of woods, are

are nothing else but extracts in solution, in which they dip and keep immersed for a longer or shorter space of time during their ebullition, threads and stuffs previously impregnated with solution of alum, or some other mordant, in order to precipitate and fix upon them the extractive matter. I shall revert to this subject in one of the subsequent articles.

ARTICLE XI.

Of the Eighth of the immediate Materials of Vegetables ; of the Fixed Oils.

A. Situation.

1. OIL, or the oily substance, in general, is one of the immediate materials of vegetables, the least soluble in water, and is eminently distinguished from all others by its combustible property, and by the bright flame which it emits during its combustion. It is long since it was first remarked that the oil formed by vegetables is one of the products of vegetation, that there is no mineral oil, properly so called, and that what is sometimes found amongst the fossils originates from plants, and cannot be composed in the bowels of the earth.

2. The special and distinctive character of fixed oil is, that it is not raised easily, and without alteration into vapour by the action of fire ; and it is opposed by this character to volatile oil.

oil. It was formerly termed fat oil, *oleum unguinosum*, or mild oil, as it enjoys both these properties; and expressed oil, because it is constantly obtained by expression.

3. Amongst the properties by which it is distinguished, I especially remark that of being contained only in a single part of the vegetables; namely, in their seeds. It would be in vain to look for it in other organs; it is never found either in the roots, the stalks, the barks, the leaves, or the flowers. Sometimes, though rarely, it is situated in the parenchyma, or the pulp of certain fruits; moreover, amongst the numerous oleiferous plants of our climates only the olive can be mentioned, as containing it in its soft external skin, and on the outside of its kernel. Generally it exists only in the cotyledons, and it is even found only in those that have two cotyledons. I know no example of a monocotyledonal plant with an oily seed.

4. All the dicotyledonal seeds that contain oil, are at the same time charged with mucilage and fecula, and they have all a character by which they may be distinguished; namely, that of forming with water in which they are triturated, a white liquor which is termed emulsion, milk of almonds; on which account they are termed emulsive seeds. They manifestly owe this property to the oil which they contain between the particles of their parenchyma. The water, by dissolving the mucilage, and dispersing in some measure between its own particles,

ticles, those of the starch, retains in suspension small drops of oil, which destroy its transparency, and give it a milky opacity and whiteness. Accordingly, when this milk of almonds is kept for a long time in contact with the air, a portion of the oil separates at its surface in the form of a greyish or semi-transparent cream; this layer separated at the surface, forms, even at the end of some days, real oily drops. During this separation a portion of the fecula is deposited in a white powder, and the liquor becomes clear in proportion as this double separation of the two substances, that were disseminated in it, is effected by repose. The acids bring about this kind of decomposition in a much more speedy and powerful manner.

5. This exclusive presence of the fixed oil in the interior of the dicotyledonal seeds, is a fact that has not yet sufficiently engaged the attention of chemists. It may, however, throw some light upon several parts of vegetable physics, as it manifestly depends upon the structure, the intimate nature, and the functions of the seeds. I shall content myself with observing here, in a general manner, that the fixed oil, which is mild and nutritious, accompanies the embryo in the seed like the chick in the egg: that it is situated in a particular place in these seeds, like the oil of the egg in the yolk: that it gives to the mass of cotyledons the property of forming with water a kind of vegetable milk, like that the egg gives to the yolk,
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the property of forming with water what is termed pretty accurately *lait de poule* ; finally, that it contributes, in the period of germination, to the first nourishment of the plant, as the yolk serves for the nutrition of the chick during incubation, and previous to its leaving the egg, and that it seems to characterize the dicotyledonal plants in opposition to the monocotyledonal, in the same manner as the oviparous animals, whose young enjoy only this kind of lactation in the egg, are opposed to the viviparous, which receive milk from the mother after they have left the uterus.

B. Extraction.

6. FIXED oil being contained ready formed in the parenchyma of the seeds, or of some fruits, nothing more is required than to press this parenchyma more or less forcibly, in order to make it run out, and to obtain it separate. But the manner itself in which it is contained or inclosed in the parenchyma, its abundance compared with that of the other substances that are mixed with it, or with which its particles are surrounded, its more or less liquid state, and its greater or less disposition to run, are many circumstances that must influence the art of extracting it, and determine modifications in the practice of this art.

7. Frequently nothing more is necessary than to bruise the seeds, reduce them to a kind of pulp or cake, afterwards to subject this paste, inclosed

inclosed in sacks of hair, or cloth, to the action of the press, in order to cause the oil to run out in such a manner that it can easily be collected. This is the operation practised in the pharmaceutical laboratories, in order to obtain the oil of almonds, and the oil of linseed; they are then termed cold-drawn oils, and a similar or equally simple process is followed for extracting the oil of hazelnuts, of walnuts, of hemp-seed, of colza, of rape seed, even the oil of olive, the oil of beech-mast, the oil of poppy seed, and a great number of others analogous to these in their nature and their uses.

8. But it is observed that most of the seeds yeild by this process only a small quantity of oil, and that though it is very pure, and very mild, such as is requisite for medicinal uses, it is too dear on account of its scarcity for most of the purposes of life, or the arts for which it is destined. We even meet with some seeds, which, containing together with the oil, a more or less considerable quantity of gummy mucilage, or of light and highly divided fecula, yield hardly any oil by the mere pressure of their paste in the cold, or else yield it only with extreme difficulty. Those even from which all the mild and fixed oil which they are capable of affording, has been extracted by the first process, still retain a portion in sufficient quantity for it to be possible to obtain much from them by a second manipulation.

9. In the case which I have just indicated, a more or less violent heat is employed, according to the substances which we have to treat, according to the more or less condensed nature of the oil which they contain, of the fecula, or of the mucilage, of the receptacle, from which they must be extracted, according to the more or less important uses to which they are destined. Sometimes we content ourselves with heating plates of block tin, which are applied immediately to the paste of the seeds, and which compress them by the approximation of the peices of the press, in order to give more fluidity to the oil, as is done with the sweet almonds; at other times the paste itself is exposed to the vapour of boiling water, in order to penetrate it with a gentle heat, which favours the separation and the escape of the oily juice. For the less important oils, the seeds are more or less strongly roasted, in order to thicken or dry their mucilage and fecula, to bring the oily molecules to their surface, and to begin to cause the drops to exsude outwards. This last process is particularly employed for the very mucous and very viscid seeds, which at the same time contain a large quantity of water. The oils that are extracted by this manipulation, which is employed for linseed, and hemp-feed, are less pure, less mild, and less fine than the first; they are also more coloured; but they are at the same time more abundant and more easily preserved. When
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the feeds have been too much roasted, the oil is reddish and has a more or less strong empyreumatic taste.

10. The fixed oil that is obtained by the processes that have been indicated, is always mixed, and even combined with some foreign substances, and especially with mucilage, amy-laceous fecula, and colouring matter. Frequently these three bodies, and especially the two latter are spontaneously deposited from the oily liquid, when it is kept at rest for some time; we see mucous flakes, coloured fibrils, or slight feculent powders gradually precipitated to the bottom of these oils; these, which at first were opaque or turbid, at the moment when the action of the press expelled them from the paste of the feeds, become clear, and more or less transparent and pure when left to themselves. The gross portion of the parenchyma, which has been carried along with the first portions of expressed oil, is separated and precipitated first, afterwards the green and coloured fecula, then the amy-laceous fecula; and the gummy mucilage is deposited the last, but frequently there even remains a portion in real solution or combination with the oily juice: it is this portion which forms what Scheele has termed the sweet principle of the oils, of which I shall speak hereafter. It is this that gives to the oil, when burned, the thick flakes which render it turbid, and more or less diminish its combustibility. Sometimes
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a portion of the green fecula, as we see in the oil of olives, remains in solution in this body, and communicates to it the colour and the taste of the fruit.

11. We see from what has been said that mere repose is not always sufficient for purifying the oils; filtration through sieves or linen, with more or less wide interstices for separating the grosser part, is likewise only a mechanical means, which takes away merely the foreign matters which are interposed: the effect of time separates indeed, especially with certain oils, a portion of the mucilage or of the light fecula which are dissolved in them; but there is another part, and some oils contain a large quantity of it, which remains really dissolved in them, and is never separated from them by rest, at least unless the oil itself undergoes an alteration, and communicates to these bodies properties which oppose the combination of advantages which we expect from them. It is especially in order to render them more pure and more easily as well as more completely combustible that we endeavour, by different processes, to free them from the foreign substances that are combined with them. Chemistry has not yet exactly determined the different states of lamp-oils, and the real causes of their bad qualities. The processes also that are employed in some manufactories or work-shops for purifying these oils are a kind of empirical practices, or methods which Science has not yet examined.

12. These processes of the arts or of the workshops in which oil is employed are very much diversified, and frequently constitute a kind of secret. It appears that in some, after having suffered the oils to rest, and filtrated them, they beat them up with water; in others they heat them gently for a longer or shorter space of time. There are some in which the oils are treated by acids diluted with water; and this process must in fact separate the mucilage from them. There are others in which they are treated by lime or the alkalis, which appear to absorb an acid holding mucilage in solution, and to favour the precipitation of this mucilage. It is also asserted that in some work-shops they use alum, whilst in others they employ chalk, gypsum, argil, or ashes for effecting the purification of the oils. It is evident that if each of these means succeeds, it is to be concluded, that the matters which render the oils impure must vary according to the species; but it is of much greater importance to be observed that an accurate chemical examination of these liquids will alone enable us to throw upon this subject the light which the science is capable of diffusing over it, and that after such an examination this art so useful to society will no longer be involved in obscurity.

C. Physical Properties.

13. FIXED oil is generally a liquid rather thick or viscid, forming streaks that adhere to glass, of a mild or insipid taste, sometimes a little acerb, or analogous to that of the plant from which it proceeds; without any peculiar smell, but frequently also impregnated with that of the seed from which it has been extracted.

14. Fixed oil is never entirely void of colour; frequently it has a greenish or yellowish hue: that which is green when recent, loses this cast in the course of time, and assumes a yellow shade, which at length becomes deeper and inclines towards the orange or the red. In general it is lighter than water, swims upon its surface; and its specific gravity, taking that of water at 10000, varies between 9403 for linseed oil, and 9153 for olive oil.

15. This body, when exposed to the cold, congeals and even crystallizes, or assumes a solid and granulated form by cooling; but this property varies in it in a singular manner according to the species: there are some that become fixed at five or six degrees above 0, and others, on the contrary, are not congealed, unless at 10 or 12 degrees below 0; there are even some that never become solid by the effect of cold. It is generally observed that those which become fixed the most speedily, like the oil of olives, are the least alterable, the
least

least subject to change, and that, on the contrary, those which are very difficult to be congealed, are the most subject to spoil, to become rancid, &c.

D. *Chemical Properties.*

16. FIXED oil, exposed to the fire, is not volatilized unless when it is boiling, and hence it derives its name; but in this volatilization it is altered, loses some of its principles, tends to be decomposed; the carbon is partly insulated in proportion as the oil is heated; the volatilized portion is more hydrogenated and lighter; water is formed, and an acid analogous to that of the fats, which is termed *sebacic*. There remains in the retort black and coaly traces; and carbonated hydrogen gas is disengaged. Such is the collection of the phenomena which take place in the distillation of the oils, which the ancient chemists performed in order to obtain what they termed the oil of Philosophers. The volume of the air contained in the apparatuses contributed also to its production in a more or less efficacious manner, because there is more water formed, and carbon insulated, as the capacity of the distilling vessels is larger; so that by repeating the distillation of the same oil a great number of times in new apparatuses, we at last constantly reduce it almost entirely into water, carbonic acid, carbonated hydrogen gas, and coal.

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17. The phenomena of the combustion of oils, when heated in contact with the air, are the same as the preceding, except that its decomposition is more rapid and more complete. It is well known that they cannot be burned unless when violently heated, that the use of the wick employed in lamps is to raise the oil in vapour by successive portions; that in the ingenious lamp of Argand and Lange, by disposing the wick in a circular form, and surrounding it with a double current of air, by increasing the activity of this by the addition of a transparent tube of glass round the wick, and especially by giving this tube a contraction at the very place where the extremity of the wick usually exhales smoke, the combustion of the oil is rendered much more complete and rapid, the flame more brilliant, the smoke and smell annihilated, as both are entirely destroyed, and that the product of this complete combustion is only water and carbonic acid. 100 parts of oil ought to yield 130 parts of water, as they contain, according to Lavoisier, 21 parts of hydrogen, and 203 of carbonic acid, since they contain according to the same author 79 parts of carbon; now the sum of these two products being 333, 233 parts of oxygen must be added to 100 parts of oil in order to make it burn. This result, which certainly is not very accurate, but which approaches to the truth as near as can be, in a first experiment, supposes indeed that there is no oxygen in a fixed oil, that it is

composed only of carbon and hydrogen, and it is probable that it includes some error in this point of view; but it is certain and well ascertained that oil is reduced only into water and carbonic acid by combustion, and that it affords more water and likewise more carbonic acid than its own weight.

18. A very different effect takes place with the fixed oil when exposed to the air without heating it, as to inflame it; it gradually thickens, becomes concrete, opaque, white, granulated and similar to tallow. This change takes place very quickly, and requires only some days, if we greatly extend the oil upon the surface of water, as Citizen Berthollet has discovered. This effect is owing to the oxygen which they slowly absorb; they become a kind of wax; they even experience this alteration in the living vegetables, by a disposition which I shall describe in the next article. Some fixed oils become dry, and these are termed drying oils. Some undergo the cerification or sebification very quickly; others, on the contrary, very slowly; some as they thicken assume a sebaceous character which manifests itself in their taste and smell; they are then rancid, redden the blue vegetable colours, and are unfit to be used as food or condiment: there is also formed at the same time a small quantity of water which appears in small drops at the surface, or evaporates into the air. There take place, therefore, in this
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flow action of the air three very distinct effects upon the fixed oils. The first is a simple absorption of the atmospheric oxygen, which thickens them and tends to convert them into wax; the second is a disengagement of their hydrogen, which burns at their surface, forms water, and dries them themselves without cerifying them; the third is the production of the sebatic acid which depends upon a new union, and in a determinate proportion, of hydrogen, of carbon and of oxygen: this constitutes rancidity. Every species of fixed oil experiences in a different manner one or other of these effects, sometimes insulated, sometimes combined; so that some are cerifiable, others drying, and the third rancescent. There are some that do not undergo any of these alterations without much difficulty. These different modifications in the alterability of the oils depend upon their primitive combination, or the proportion of their elementary constitution, and it will be easy to ascertain their difference and their cause, when an analysis shall have been instituted of the principal species that belong to one or the other of these genera; for it shall be shown hereafter that in order to distinguish the species it is necessary to divide them according to these properties.

19. The simple combustible bodies unite more or less easily with fixed oil; hydrogen in the state of gas does not unite with it unless with difficulty.

Carbon in the state of coal, through which oil is filtrated, contributes to purify or whiten it, without sensibly uniting with it.

Phosphorus unites with the oils by the aid of heat; it fuses and dissolves in them in a small proportion, communicating to them the luminous property when they are rubbed in the air; and it is this solution which is employed for rendering any surfaces luminous and phosphoric in the dark. When we dissolve in heat all the phosphorus which the oil is capable of dissolving, by letting it cool, a part of the phosphorus is deposited by the refrigeration, and crystallizes in transparent octahedrons. By distilling the phosphorated oil, we obtain phosphorated hydrogen gas.

Sulphur combines easily with fixed oil by means of heat; whence results a reddish solution which has formerly been termed *Ruby of Sulphur*, on account of its colour. This solution deposits crystallized sulphur by refrigeration; it is even the only process by which Pelletier has obtained the sulphur crystallized in octahedrons. When the refrigeration is too rapid, yellow sulphur is precipitated in needles. If we distil this sulphurated oil, which has a fetid smell, a large quantity of sulphurated hydrogen gas is obtained, without the sulphur subliming in its concrete and insulated state.

Some oils exert an action upon the metals that are the most easily oxidated; they accelerate their oxidation, and favour the absorption
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of the atmospheric oxygen ; but this effect is in general feeble and slow. The metallic oxides have a much more marked action upon the vegetable combustibles ; by the aid of heat, they yield a portion of their oxygen to the oils, which then become thickened, and form in general the substances known by the name of *plasters*. In this state they form kinds of soaps frequently insoluble, sometimes more or less soluble. If we augment this action by that of heat, we intirely decompose the metallic oxide ; it passes again into the state of metal, and the oil is then intirely destroyed into water, and carbonic acid. It is this which causes plasters to assume a coppery-red colour, and most of the ointments, or plasters, that have been too long boiled, acquire a brown or blackish colour, by the reduction of the oxide of lead.

20. Water has no sensible action upon the fixed oils ; they remain upon the surface of this liquid. When agitated with it, they first whiten it and interpose themselves between its particles ; but they separate again from it by repose. Water, however, takes from them a certain proportion of mucilage, and favours the separation of the colouring fecula, which troubles their transparency ; this is a means used in work-shops for purifying them and rendering them more combustible.

21. The acids are capable of decomposing the fixed oils, but with particular phenomena, according to the nature and the concentration of these

these acids, as well as their quantity and different temperature. In general, the concentrated sulphuric acid renders these oils brown, thick, and reduces them to coal. This action has formerly been compared to the formation of a resin, or of a bitumen; but it is really neither the one or the other; it is a commencement of decomposition, in which water is formed; carbon is separated and precipitated, and even an acid is produced. The cold nitric acid thickens and slightly oxidates them; if it be mixed with nitrous gas, it acts with much greater activity; it excites a considerable ebullition and effervescence, and a large quantity of nitrous gas is disengaged. When we throw upon oils a mixture of concentrated nitrous and sulphuric acids, they immediately inflame, and leave a coal more or less inflated and voluminous. By employing nitric acid with caution, we may effect the exact analysis of an oil; we convert it into oxalic acid. The ordinary muriatic acid produces very little effect upon fixed oil; the oxygenated muriatic acid thickens and whitens it like tallow or wax.

22. All the alkalis exert a more or less remarkable action upon the fixed oils; they all render it soluble, and reduce it to the saponaceous state; the name of *soap* is even applied in a particular manner to this combination of a fixed oil with an alkali. The medicinal soap is made by triturating in a mortar of glass or marble, one part of caustic ley of pot-ash, weighing at least one half more than water, with

with two parts of oil of sweet almonds. Trituration in the cold is sufficient to effect this combination. With oils of inferior quality, and a caustic ley of soda, a little concentrated and well mixed, the common soap is prepared, which becomes solid in the course of time. Most commonly this combination is promoted by heat, in order to concentrate the ley; the liquid portion is afterwards separated; when ley of pot-ash is used only a soft soap is obtained. That which is termed *marble soap*, is made with crude soda, sulphate of copper, cinnabar, &c. The most ordinary sorts, which are termed *green* or *black* soaps, are manufactured with the marc of oil of olive, of nuts, of rape-seed, and the caustic alkalis treated by ebullition. The reader may consult, for the economical practice of this art, the instruction published by Citizens Darcet and Pelletier.

23. Soap, properly so called, or the combination of a fixed oil, with caustic soda, is a white, solid, acrid and alkaline substance, very fusible in the fire, absorbing a very large quantity of water, which greatly increases its volume; losing this volume and becoming very light by exposure to dry air, or by a gentle fire, from which the alkali gradually separates in the form of crystallized carbonate of soda by long exposure to the air; decomposable by fire, and yielding its oil, part liquid and part solid, by distillation; very soluble in water, with which it unites in all proportions; forming either

a thick liquid filled with white, and as it were silky filaments, when this solution is strong and concentrated, or an almost transparent liquid, when the water contains but little of it; giving to this liquid, besides a soft, and as it were greasy feel, an acrid urinous taste, a milky semi-transparency, the property of forming much lather, and affording a kind of foam, which easily retains the air, and the gases under thin and tenacious tegument, as is exemplified in the simple art of making what are called soap bubbles; decomposable by the acids, which separate from it the oil, thick and more or less approaching to the state of tallow or wax. We see by all these first phenomena that belong to soap, that in the union of the oils with the alkalis by which it is formed, the fixed oil has absorbed a more or less considerable portion of oxygen; and that it is on this account that the contact of the air influences the saponification; that soaps are made more quickly and of better quality with the most concrescible oils, or those which are most disposed to concrete, or even with those that have already become concrete, especially with the fats, &c. that it is also by this more speedy oxidation, favoured by the presence of the alkalis, that the soaps become solid, and that concrete oil is separated from them by the action of the acids, and even of fire.

24. True soap, or that prepared with soda, is also distinguished by the property of being decomposed by means of barites, strontian, and

and lime. Its solution in water, mixed with that of these bases, suddenly forms a precipitate in white insoluble flakes, which when chemically examined, is found to be a compound of the concrete oil with the base employed. All the soluble salts of these same bases, as also those of magnesia, of glucine, of alumine, and of zircon, produce an insoluble precipitate analogous to soap, in the solution of soap of soda. This is the reason why this saponaceous compound cannot dissolve, but, on the contrary, assumes the form of curd, with waters charged with any earthy salts. A similar phenomenon takes place with all the metallic solutions and salts. As soon as we pour these solutions into that of soap, precipitates are formed, which are compounds of the metallic oxides with the oil; these precipitates have different colours, according to the different oxides; their coloration is constant and fixed, according to Citizen Berthollet, who, in giving an account of these compounds under the appellation of *metallic soaps*, has proposed them to be used in painting.

25. Ammonia also reduces the fixed oils to the saponaceous state; but its more feeble attraction never brings them to the concrete state, or favours their oxidation, as is done by the fixed alkalis: accordingly it never forms any thing more than saponaceous liquids, more or less opaque, though soluble in water, and capable of forming a lather, as also of taking out oily spots like the solid soaps. For the rest, the ammoniacal soaps exhibit most of the properties of the ordinary soaps.

26. No

26. No salt acts in the cold, and really unites with the fixed oils. The sulphates, with the aid of fire and a red heat, are decomposed by the oils then reduced to the state of hydrogen and carbon. The nitrates burn and decompose them at an elevated temperature. The muriate of soda is frequently employed for hardening soaps. The super-oxygenated muriate of pot-ash, triturated with a little fixed oil, and violently struck, suddenly inflames and detonates.

27. Some metallic salts mixed with the oils are decomposed and precipitated by these substances, which separate and dis-oxidate their metallic bases. This is particularly observed to take place in the mixtures which are made for several emplastic compositions. But this effect has hitherto been but little examined, though it merits the attention of chemists.

28. The fixed oils unite artificially with mucilages and sugar; by triturating them with these substances we render them white, opaque and more or less miscible with water: this operation is frequently performed in the laboratories of pharmacy.

E. *Species.*

29. I HAVE already shown that the species of the fixed oils might be distinguished by the aid of their chemical properties. I ought to add, that this method of distinction is so much the more essential and necessary, as the number of these vegetable productions is extremely considerable. Every country, every climate, according to the differences

differences of the vegetables which are cultivated in them, has different oils appropriated to a multitude of domestic and economical uses. It would even be superfluous here to present the enumeration of all the different species of oils that are extracted and employed in different places. I shall therefore confine the enumeration which I propose to give, to the principal species known and employed, especially in Europe, and particularly in my own country.

30. I shall here more particularly distinguish the fixed oils in common use into two genera. The first shall comprehend the *fat oils*, which have the character of becoming fixed more or less speedily by the action of the cold, of thickening but very slowly in the air, and of being converted by it into tallow or wax. These oils have also the property of being less alterable by the acids than the others, of easily forming soaps with the fixed alkalis, of being inflamed only by the nitric and the sulphuric acids combined, and of becoming more or less speedily rancid when kept in hot and moist places, in contact with the air. It is especially in these fat oils of the first genus, that we find the mild principle of Scheele in the greatest abundance. This chemist discovered that by combining the oil of sweet almonds, of olives, and of rape-seed with the oxide of lead, by the assistance of heat, and adding a little water to the mixtures, there was separated from these oils a supernatant liquid, which furnished him, by evaporation, a matter

matter of the consistence of a syrup, which took fire by being strongly heated, of which one part was volatilized without burning in distillation, which afforded a light coal, which did not crystallize, and did not appear to be susceptible of fermentation. The nitric acid, distilled four times upon this mild principle, changed it into oxalic acid. These characters remarkably approach this substance to the mucilages, as I have already indicated, and I refer it to the mucous principle.

31. In this first genus of fixed and fat oils, I rank, especially, the oil of olives, the oil of sweet almonds, the oil of rape-seeds, or colza, and the oil of ben, the four species which are the best known and the most employed in France.

A. The oil of *olives* is the only known species that is extracted from the pulp of a fruit exterior to the kernel, or a species of husk. The olive is bruised by a mill-stone placed vertically and turning upon an horizontal plane; the paste produced by this operation is subjected to the action of a press which causes the virgin oil to run out of a greenish colour, and with a strong taste of the fruit. The marc or pulp is afterwards moistened with boiling water, and pressed anew, in order to obtain the ordinary oil. The unripe olive yields a bitter oil, and that which is too ripe yields a pasty one. If the mills are not kept very clean, they remain impregnated with a rancid oil, which gives bad qualities

qualities to that which is afterwards fabricated in them. Olives that have been kept heaped together too long, and that have fermented, yield a strong oil, which can be used only for making soap. The oil of olives congeals or crystallizes at 10 degrees below 0, and does not become rancid except after an exposure, of ten years to the air. It is an aliment and condiment very much employed, and very useful in the Southern Departments of France.

B. The oil of *sweet almonds* is extracted from almonds which are first violently shaken in a sack of coarse canvass, and roughly rubbed, in order to separate from them the acrid powder which covers their epidermis. They are pounded in marble mortars; the paste is afterwards subjected to the press, and the oil issues out a little greenish and turbid, and, like the oil of olives, deposits a sediment by repose.

C. Oil of *rape-seed*, and oil of colza, are the names given to those which are extracted from the seeds of two species of cabbage, the first from the *brassica napus*, and the second from the *brassica arvensis*; this oil, which is very good, does not dry, is less fixable and less rancid than the two preceding; it is much prepared in Flanders.

D. The oil of ben is extracted from the kernels of ben, which is very abundant in Egypt and Arabia; it is void of smell, but very susceptible of rancidity, so that it very quickly becomes acrid; it easily congeals. As it is in-

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odorous

odorous, it is particularly appropriated to perfumery.

We may subjoin to these four first species, the oil of beech-mast, that of grape-stones, that of the seeds of the sun-flower, and that of several species of cruciferous seeds, which are of a nature analogous to the preceding.

32. The second genus of fixed oils includes those which I call *drying*; their characters are that they dry in the air, at the same time preserving their transparency, and without becoming a kind of tallow or wax. They do not become fixed, concreted, or crystallized by the cold, nor become rancid so easily as the preceding, nor do they form soaps so easily with the alkalis, nor inflame by the contact of the nitric acid furcharged with nitrous gas, without the addition of sulphuric acid. They appear to contain less mucilage than the preceding: accordingly, the linseed oil excepted, Scheele does not indicate them amongst those in which he says he has found the mild principle. It is also very probable that they owe their particular nature to another order and another proportion of combination in their primitive principles.

33. I also rank four principal species of fixed oils in the second genus of oils designated by the epithet of *drying*: namely, oil of linseed, oil of nuts, oil of poppies, and oil of hemp-feed.

A. The oil of linseed is extracted, as I have said, from the seeds of flax, either in the cold,

cold, and then with difficulty and in small quantity; this is what is appropriated to medicinal uses; or after having torrefied those seeds in order to dry their mucilage, and facilitate the separation of a larger quantity of oil: this, which is more or less roasted, burned or reddish, has a taste which indicates its origin, as well as the alteration which it has experienced. It is destined especially for the arts, for painting, and for fat varnishes. It has a very bad taste; it burns ill, and thickens in the air, though slowly and with difficulty. In order to render it more drying it is boiled with a little oxide of lead or litharge, and it is then sold by the name of boiled linseed oil. It is in this state that it is employed in the preparation of the fat lute of the chemists.

B. The oil of nuts is extracted from these kernels after a slight roasting, or without the action of the fire. The latter, when prepared with care, is pretty good, and is used as food and condiment by a great number of the inhabitants of some of the Southern Departments of France. When it is extracted from old nuts, more or less rancid and roasted, it has a very bad taste, and can hardly be employed except for coarse painting; it thickens and dries pretty quickly in the air.

C. The oil of poppies is separated from the seeds of the poppy, which, on account of its beautiful flower, is called *oeillet* in the Northern departments of France, where it is cultivated

tivated in great abundance. This oil is very beautiful, very clear, considerably drying, without any disagreeable smell or taste, when it is well prepared. It is frequently employed as a condiment, and it is often sold for oil of olives; the latter is even seldom sold without an addition of oil of poppies: this oil has no soporific property.

D. The oil of hemp is expressed from the seeds of hemp; it has always a harsh disagreeable taste, and it is never used as a condiment. It is very drying and very thick: it is used only for some kinds of painting.

F. Uses.

34. **FIXED** oil, in general, is a mild substance, and is used for nourishment, or for the seasoning of food. Accordingly the seeds which contain it are the principal food of animals. It is used only as seasoning to the aliments which man prepares, the form of which it varies in a singular manner; when alone it is not easy of digestion; accordingly it is scarce ever employed in this separated state, but mixed with different substances, and especially with the vegetable acids.

35. In medicine the fixed oils are employed as emollients, relaxants, and, for allaying pains and irritations, diminishing the dryness of coughs, destroying the impressions of acrid matters and poisons. Formerly much more use

was

was made of them than is now done. It has been discovered, since the middle of the eighteenth century, that oily substances are frequently more prejudicial than salutary to health, that they load the stomach, aggravate fever, increase the disposition to putrescence, and at present it is only ill-informed persons who make a frequent use of them. They are generally administered with syrups; they are frequently prescribed triturated with gums, sugar and water, in the form of loches; they are employed in pharmacy in the preparation of a great number of chemical and pharmaceutical compound medicines, of ointments, plasters, oily balsams, medicinal soaps, liniments, &c.

36. The oils are employed for a great number of uses in the arts; they serve to preserve many substances which are covered with them, or kept immersed in them; for softening leather, and skins; for preparing fat varnish; for mixing the colours used in painting; for spreading on a number of bodies in order to render them smooth, soft, or flexible, and to defend them from the action of the water and the air; in the preparation of *mastics*; for affording light by their combustion in lamps; for favouring the effect and the motion of metallic machines; in the manufacture of soaps, &c. &c.

ARTICLE XII.

Of the Ninth of the immediate Materials of Vegetables; of the Tallow and the Wax of Plants.

A. Situation.

1. I HAVE enumerated amongst the characteristic properties of the fixed oils, their power of thickening in the air, and of thus forming, by the absorption of oxygen, a sebaceous or waxy matter. This character shows itself in all cases where the fixed oils issue from the plants, and are spread out in the atmosphere. As it is then in small drops, more or less minute, that these liquids exude from the plants, being exposed by this disposition to the contact of the air, they attract oxygen more or less speedily, and become concrete, so as to become a kind of tallow or wax.

2. It is in this manner that a waxy or sebaceous matter is formed upon the catkins of the poplar, of the elder, of the pine, upon the leaves of rosemary, of sage, on the surface of the fruit of the *myrica cerifera*, of the *croton sebiferum*, and of a multitude of other seeds or vegetable capsules. But the most abundant, the most common, or rather the most general of these formations of concrete oily substance, more or less waxy, is that which takes place in most plants at the extremity of their stamens,
and

and on the external surface of the anthers with which they are terminated. This latter membranous organ, which has been compared with the testicles of animals, presents to the observer, at the moment of fecundation, a greenish or yellowish powder, granulated, fatty to the touch, which is very easily detached by the slightest motion or rubbing of the anthers. A great number of observations prove that it is of an oily or inflammable nature: the daughter of the celebrated Linnæus has even shown that, when reduced into vapour by the action of the sun, this dust of the antheræ, which however is not the real fecundating part, but only its reservoir or vehicle, inflames at the approach of a combustible substance in the state of ignition, and presents the same phenomenon which is observed in the *fraxinella*.

3. Though Reaumur was not able to convert this powder into real wax by the different means which he has employed for this purpose; though the experiments which I myself have instituted upon the powder of the stamens of the male hemp, did not meet with the success which I hoped, it cannot be doubted that it is from this pollen that the bees extract the substance with which they construct their combs: after having collected and worked it into small balls with the brushes with which Nature has furnished their paws, they carry it into the hive; they swallow it, reject it by the mouth, knead it with a humour that proceeds

from their bodies, give it the softness and ductility which it must have in order that they may be able to work it in the construction of their combs; and whether this change in the pollen be owing to the heat of the hives, or proceeds from the mixture of an animal humor with which they cover it, or finally whether it be the consequence of a digestion, or any alteration produced by the action of their stomach, it is certain that the wax of the bees has no other origin than the pollen of the stamina of flowers, which it resembles in many of its properties.

Sometimes the vegetable concrete oil, tallow or wax, is found in the internal part of fruits or seeds, and seems then to owe its formation and its nature to a combination of oxygen in the interior of the vegetable texture itself. It is in this manner that the parenchyma of the seed of the *croton sebiferum*, and of several other vegetables, especially the seeds of the caca, of the nutmeg, of the coco, contain a substance analogous to butter or tallow. I have observed that several of these seeds present at their external surface a more or less thick layer of real wax, well dried, concrete and brittle, whilst their internal parenchyma is impregnated with a less concrete oil, or a kind of tallow, more fusible, more soft, and much less resembling wax, which proves that the contact of the air gives to the first a much more solid state, a more marked oxygenation.

B. *Extraction.*

5. THIS kind of wax or tallow cannot be extracted from the vegetable matters which contain it in the same manner as is done with respect to the more or less fluid fixed oils. The solid state of these bodies opposes it; we are obliged to expose them at first to a degree of heat sufficient for softening or melting these substances. At this temperature, which we communicate to the bruised seeds, or to the fruits that are covered with it, we may frequently, by afterwards subjecting them to the action of a press, cause this matter to run out. It is in this manner that it is extracted in pharmacy from the kernels of the cacao, slightly torrefied, reduced into paste, and afterwards pressed with more or less force.

6. A more commodious and surer means for obtaining this concrete oily substance is almost always employed. The seeds or the intire fruits that contain it in a thin layer applied over their external surface, are boiled. The heat of ebullition fuses this concrete substance, and renders it very fluid; it then detaches itself from the integument to which it adhered, and collects in a liquid layer at the surface of the water. This is suffered to cool, and it is afterwards separated very easily when it has become fixed in a solid plate at the surface of the water.

This

This process is especially employed for obtaining the wax of the galé, and sometimes for collecting the butter of the cacao; it may be employed in general for all the vegetable matters at the surface of which this concrete oily juice is collected and thickened into a solid layer. When it is practised with the catkins of the poplar, the alder, the birch, the fir, small quantities of a kind of wax or tallow are extracted.

7. In those cases where the vegetable fruits or grains contain, as is particularly exemplified in the *croton sebiferum*, two kinds of concrete oily juices, the one more solid and of a waxy nature at the surface, the other softer and of a sebaceous consistence in the internal parenchyma; we may combine both the processes that have been indicated in order to obtain each of these bodies separate. We first boil them whole in water, which separates the external wax; and when they are deprived of this they are bruised and expressed, after having heated them in order to extract from them the tallow. It appears that in China this two-fold practice is employed in order to obtain separately the vegetable wax which is employed for making tapers for the opulent, and the tallow which is used for preparing a kind of candles destined for those who cannot afford to purchase the others. I have performed this experiment upon the seeds of the croton, and have obtained two matters very well distinguished by the solidity

dity and the concrete state of the first, as well as by the softness, the greasiness and the fusibility of the second. It was in this manner I discovered that this differs also from the first by a very marked purgative property.

C. *Physical Properties.*

8. THOUGH the concrete oils all resemble each other in their consistence, they have, however, neither the same texture nor the same solidity: some are mild, homogeneous, of a fine texture, and like butter as to their softness and fusibility; they are accordingly termed *vegetable butters*, as the butter of cacao, the queyamadoa, &c. others are of a granulated texture more or less crystalline, as the butter of coco, the tallow of croton. Lastly, there are some of a firmer consistence resembling real wax, like that of the (galé,) the wax of the wax-tree of Louisiana, &c. Some appear capable of assuming the lamellated form. The pollen of the stamens is in small incoherent grains, and does not assume the concrete, ductile, dry, and uniformly solid state of wax, till after it has been wrought by the bees.

9. The taste, the smell, the colour, are also properties of this concrete oil that admit of much variation; it is sometimes white, most frequently yellow or fawn colour, sometimes brown or green, seldom red. Though the most of them
are

are insipid, some are acrid, austere, or more or less pungent. Some are inodorous and others have a perfume. It is true that the latter most frequently owe this property to a portion of volatile oil which is more or less intimately and abundantly united with them, as we see in the butter of the nutmeg, and in all those which proceed from aromatic fruits or seeds.

10. We also find the same variation in the fusibility of these substances, from the extreme softness of the butter of Galam, to the dry, brittle, and consequently less fusible state of the wax of galé, and that of Louisiana. This fusibility commences between twenty-five and thirty degrees of Reaumur's thermometer, and extends to above sixty, as we see in wax, properly so called, the purest and most valuable of these matters of vegetable origin.

D. Chemical Properties.

11. ALL the chemical properties of the butters and the waxes of plants, whilst they approach more or less to those of the fixed oils, present, however, differences which depend upon their concrete state, and the proportion of oxygen which these oily juices contain. This difference shows itself at first, both in their distillations and in their combustion. When we distil them, we obtain water from them more easily; they yield more sebatic acid; they afford an oil suffi-

sufficiently thick and concretescible, which is called *butter of wax*; we extract from them at last less hydrogen gas but more carbonic acid. The case is the same with their combustion; they do not require so much air in order to burn; they yield a whiter flame, less smoke and carbon; they burn more uniformly and more easily than the fixed oils. The use of candles and tapers evidently proves these first facts. When gently heated, this body becomes intirely volatilized.

12. Most of these concrete oily bodies which are coloured lose this colour by degrees, which is destroyed by the contact of the air and of the atmospheric water. When they are exposed in small fragments or thin slips to the contact of the air, they lose their colour and become white; this is what happens with wax when bleached, by leaving it upon the meadows and wetting it with water, whilst at the same time it is exposed to the rays of the sun. This colouring part has been compared with that of silk.

13. Some combustible bodies unite still more easily with these sebaceous and waxy matters, and frequently experience more alteration from them than from the fixed oils properly so called. Sulphur and phosphorus unite with them by fusion. The metals that are easily oxidable are burned by them more or less quickly. Citizen Berthollet has found that by melting wax upon copper filings, and suffering it to remain upon

them for some time, this metal was much more speedily converted by it into green oxide than it is by oil; and it is very evident that this effect depends upon the oxygen fixed in the wax.

14. It is for the same reason that the powerful acids exert scarce any action upon the concrete oils: as the fixed oils are altered by them only in consequence of their attraction for oxygen; the oily juices that are saturated with it have no longer the same cause of alterability; accordingly we meet with much greater difficulty in attempting their analysis by these burning bodies. The oxygenated muriatic acid which thickens the fixed oils, produces no such effect upon these concrete oily juices, and only whitens those whose colouring part is susceptible of destruction by oxygen. It is in this manner that the green wax of Louisiana is very quickly whitened by being merely immersed and remaining for some hours in this acid.

15. The facility with which the alkalis unite with the tallows, the butters and the waxes of vegetables, confirms what I have said above concerning saponification. It is evident that it is to the oxygenated state of these concrete matters that they owe the property which they possess of combining and forming soaps with the caustic alkalis. The soap of wax and soda is termed *punic wax*, and is frequently employed as an encaustic. These combinations possess, besides, all the

the properties of the best soaps, and may be employed with much success for the same uses. As ammonia renders the waxes likewise soluble and saponaceous; its volatility may hereafter prove of use in the arts, in which it should be an object to apply wax in a thin layer.

16. All the chemical properties of these bodies prove, therefore, that they are a kind of oxides of fixed oils, and that they owe their origin to a fixation of oxygen in these oils, to a combination without combustion, between carbon, hydrogen, and oxygen. There is reason to believe, that the chemical art will at some future period be able to imitate such a combination, by fixing oxygen in the fixed oils, by means of different processes and thus considerably augmenting their value by their conversion into artificial tallows or waxes. The first trials that have been made in this kind of research already afford the best hopes, and they only require to be followed with more perseverance.

E. *Species.*

17. UNDOUBTEDLY we are as yet far from knowing all the concrete fixed oily substances, which the vegetables are capable of furnishing; their number is certainly much more considerable than has been supposed; and if we would, or could depend upon the vague, uncertain, and frequently so little enlightened accounts of travellers,

travellers, it would be possible to present a pretty considerable list of them. But as it is impossible to establish any thing exact upon the simple assertions of most of these men, who are too little instructed to have been able to give exact notions concerning all the products of which they speak, I shall here content myself with indicating the principal and the best known species of this genus, amongst those which I have been able to subject to some experiments, or which able chemists have indicated.

18. In this view I shall here cite the twelve following species: the butters of cacao, of coco, of nutmeg, of Galam; the vegetable tallow called queyamadou, that of the *croton sebiferum*, the wax of the galé, the pela of the Chinefe, the wax of Louisiana, the wax of the catkins, of the birch, of the alder, and of the poplar, the leaves of rosemary and sage; finally the pollen of the anthers, and wax, properly so called.

A. The butter of cacao is extracted from the paste of the seeds of this plant, *theobroma cacao*, either by subjecting it to the press, after having exposed it to the vapour of boiling water, or by boiling it in water. More than a third and even nearly half the quantity of this paste is extracted from it, when the cacao is sound and of good quality. At first it is a little fawn-coloured or yellowish; it is purified by melting it again in water. It is then white, of a mild taste, slightly granulated in its fracture, very unctuous to the feel, fusible between twenty-eight

eight and thirty-five of Reaumur's scale. It is this concrete oil that gives to chocolate its mild and unctuous taste; it is sometimes the cause of the difficulty which certain stomachs experience in digesting chocolate; it is much employed in pharmacy.

B. The *butter of coco*, is found in the fruit of the palm, named *cocosnucifera*; its heated pulp is expressed: some naturalists say, that it is separated from the milk of coco in the form of cream; it is found congealed and granulated in the oils of coco that are frequently sent to Europe. It is employed as a condiment in countries where the palm abounds.

C. The *butter of nutmegs* is extracted from this seed, *myristica officinalis*, bruised, softened with water, and subjected to the action of the press; it is sufficiently solid, of an orange yellow colour, of a pleasant and aromatic odour, which it owes to the portion of volatile oil that is combined with it. It has an acrid and strong taste, which is much diminished by keeping it fused, by agitating it in a large quantity of water, and by heating it for some time.

D. There is brought from Senegal, and comes by the way of the commerce of the interior of Africa, an oily, concrete, soft and very fusible juice, which is called *butter of Galam*, from the African town where it is taken in the way of exchange; it is yellowish, almost always rancid, and acrid. It is said to be employed as a condiment in the country. The tree,

tree, or the plant, which furnishes it is not known.

E. The *Queyamadoa* is another species of concrete butyriform juice, which comes from Cayenne and Guiana : the tree whose fruit affords this butter, is called *virola sebifera*, by Aublet ; it is a myristica. This kind of butter is said to be employed both as condiment, and as a combustible substance, in the country.

F. The *croton sebiferum*, or *sapium ceriferum* of Brown, Jacquin, and Jussieu, produces in America, and in many other hot countries, fruits nearly round, the external tegument of which is covered with a layer of waxy matter, which is fused with the aid of boiling water, and collects at the surface of this liquid, where it becomes fixed by cooling. I have already observed that we may extract from the bruised kernel another matter which is less hard and less dry, more fusible, more analogous to butter. Its smell, which is sufficiently agreeable, induced some young persons who performed this experiment in my laboratory, to try it as a condiment with spinach ; it gave them all a more or less violent purging, attended with strong colic pains. It seems this depends upon the perisperma, which is always acrid and purgative in this family of plants.

G. The wax of the galé is extracted in abundance in China, and in many of the Eastern countries, from the seeds of the *myrica cerifera*, and from one or two other species

species of *myrica*, called wax-trees. Its seeds, which are round, and of a bulk nearly similar to that of the smallest coriander-seeds, are covered with a layer of white wax, which easily separates from them by the action of boiling water, and swims upon the surface of this liquid where it becomes fixed by cooling. Fine tapers are made of it. We are also assured that after having extracted this external wax, which is very dry and very similar to bees wax, the Chinese obtain from the bruised seeds reduced into a paste, another fat matter, more soft, more resembling tallow, and which they employ in the fabrication of a kind of candles, which are cheaper than the tapers of the wax of the *galé*. Abundance of wax is extracted in North America from the same *myrica cerifera*.

H. There is known in China, by the name of *pela*, another kind of ceriform juice, solid, concrete, even brittle, of a very beautiful and very fine grain, with which the Chinese fabricate the most highly esteemed wax-works. We have hitherto no accurate knowledge concerning its origin. According to the report of the missionaries, we should be led to believe that it is a wax wrought upon a tree by the insects; but they add, that the species of worm which prepares it, contains it in its interior, and that it is extracted from the worm itself. Others say, that they are kinds of small combs formed by the insects upon the leaves of the tree, which are wrought in order to extract the *pela* from them.

them. Nothing positive is yet known concerning this subject.

I. We ought to be better acquainted with the valuable and important matter which is called *wax of Louisiana*, (*myrtle wax*) and which in fact affords a wax as fine as bees-wax, the properties of which it would be very useful to study, and to increase its importation into France. This species of green, granulated, brittle, dry wax is extracted from the seeds of a tree which appears to be the same with the *myrica cerifera*, or a proximate species, but with respect to which there is still much uncertainty. Neither is it known in what manner it is extracted, though it is very probable that it is by boiling in water. It is imported into Europe in large cakes of the weight of several kilogrammes, of a greyish or yellowish colour. I have seen it of four different casts. It is bleached very quickly by exposure to the air and dew; the oxygenated muriatic also quickly deprives it of its colour, and bleaches it completely. By fusing it afterwards, we obtain a species of wax almost as fine as bees wax, and which may be employed for the same purposes. It is said that the green colour proceeds from the copper which is added to it, or from the copper vessels in which this wax is melted. There is reason to believe that the *myrica cerifera* might be naturalized in the southern departments. The *myrica galé* of the country about Paris affords no wax: it is from its name
that

that the appellation of *galé*, or *piment* has been given to that of the Chinese.

K. The male catkin of the birch, of the alder, of the poplar, and of the pine, yield, according to several authors, by boiling them in water, a kind of whitish wax, sufficiently solid, in very small quantity, and which has not yet been employed for any use, on account of its scarcity. No exact experiments have been made, and nothing positive is known respecting the properties of this oily juice, which perhaps is nothing more than a resin. I shall apply the same observation to the pretended wax, which is said to exude from the leaves of rosemary, of sage, and of several other labiated plants: if it had the relations, which it is supposed to have with that of the *myrica cerifera*, it is scarcely possible to conceive how so remarkable a fact should hitherto have escaped the very multiplied investigations that have been made respecting these plants.

L. I have already announced that the pollen of the anthers is a species of waxy matter not adhering, nor ductile, which seems to want a slight change in order to become real wax, a change which is produced in it by the stomach of the bees. It has not yet been practicable to convert the pollen of the anthers into real wax by chemical processes; but experiments have not been sufficiently prosecuted for this purpose, and every fact announces that by continuing our researches on this subject, we

shall obtain all the success that can be wished. It is known that the powder of the lycopodium, which has been erroneously considered as a resin, is very inflammable, and kindles by the mere contact of a body in the state of ignition. This powder appears to be exactly of the same nature as the fecundating pollen.

M. Wax, in some measure the last product of the concrete vegetable oils, the most solid, the most brittle, the driest, and the least fusible of these concrete inflammable bodies, the most oxygenated of all the oily oxides, is collected in the hives, in the interior of which the bees have deposited it for constructing their cells, of a colour at first fawn or yellow, but is deprived of its colour, and bleached by exposure to the air, after it has been melted into thin layers, and known in this state by the name of virgin wax; it is the most employed, and most useful of these combustible substances. Its softness, its ductility, its fusibility, its loose texture, its whiteness, even its preservation, its brilliant combustion, its dryness, its purity, and inodorous quality render it of inestimable value for the purposes of life. We shall speak of this subject in the subsequent section.

F. *Uses.*

19. THE numerous uses in which these butters, tallows and waxes of plants are employed, are sufficiently known. I have already
elsewhere

elsewhere indicated a part of them, in the enumeration of the species: as condiments, as mild aliments, as matters proper for lubricating the surfaces of a great number of bodies, as combustibles proper for diffusing a beautiful light, and dispelling the obscurity of long nights, these precious vegetable products render many services to man. They are also employed for forming the solid mass of statues, for pouring into moulds, and representing in relief all the objects whose image we wish to preserve, or to imitate their forms. The sculptor, the statuary, and the model-maker find in them materials upon which they can exercise their talents. There are, therefore, few bodies more generally employed; and accordingly all countries have their wax, or their particular vegetable butters, and all nations are careful not to neglect, or destroy the plants which furnish them.

20. Medicine has also derived very important advantages from them. The wax and the butter of cocoa answer a great number of purposes, and are applied to a series of pharmaceutical works and preparations. Sometimes they are employed as recipients, to bases of other medicines; sometimes they serve to give consistence to remedies more or less compounded, such as ointments and plasters. Their mild or insipid taste, their unctuous and relaxing quality, and their emollient property, cause them also to be employed as primary and essen-

tial remedies in a great number of cases in which these virtues are indicated.

ARTICLE XIII.

Of the Tenth of the immediate Materials of Vegetables ; of the Volatile Oil.

A. Situation.

1. THE name of *volatile oil*, in very marked opposition to the former, is given to that oily juice, which when heated, like the fixed oil, rises more or less speedily and easily in vapour. It was formerly called *essence*, and *essential oil*, because it was considered as really determining the existence or the essence of the vegetable matters which furnish it. Besides the characters of volatility, which distinguish it from the fixed oils, it has also a smell more or less fragrant and aromatic; it is on account of this property that it was designated by the names of *essence* and *essential oil*.

2. It is not with this genus of oils as with the preceding; they are not constantly distributed and insulated in the seeds or the fruits of the vegetables. Experience shows that all the parts of vegetables are capable of contain-

ing them, and that by a very remarkable contrast with the fixed oils, they are never met with in the interior of the seeds themselves. This latter fact, which has not sufficiently fixed the attention of chemists and naturalists, proves that the properties of these oils are intirely opposite to those of the fixed oils, and that their uses in nature and in the vegetable economy are altogether different; their burning acrimony would render them no less prejudicial to the embryos and the plantulæ, than the unctuous and nutritive mildness of the first renders them useful to these delicate beings. Nature has taken the same care to remove the volatile oils from the interior parts of the seeds, as she has to convey the fixed oils thither; the latter are a real milk to the young plants; the former would act upon them as a destructive poison.

3. There are a multitude of odorous, aromatic roots, more or less acrid in their taste, which contain volatile oil, but in such small cells, or in such minute vessels, that the eye cannot discern it in them, and that it cannot be extracted by mechanical means; but the smell, the inflammable property, and the more or less hot and burning taste of these woody roots prove them to contain this vegetable principle. The principal examples of roots charged with volatile oil, are the avens or bennet, elecampane, white dittany, Florentine orris-root, &c.

4. A great number of woods, especially the *fantal*, very improperly called *sandal*-wood in commerce,

commerce, and in the arts, the *lignum Rhodium* or rose-wood, the pines, the firs, the larches, and most trees of the hot climates, especially in India and America, contain more or less considerable quantities of volatile oil, which is intimately and profoundly contained in them. The aromatic and pungent barks are also impregnated with them, especially those of cinnamon, of the *caffia lignea*, &c.

5. The leaves of all the labiated plants are filled with volatile oil, and frequently even the cellules which contain it are visible or perceptible to the naked eye by the rugosities, the asperities, the tubercles which mark the surface. There are even some, like those called (in French) on that account *mille-pertuis*, that present to the eye very numerous transparent points, which have been taken for holes, but are merely small cellules, covered only by the epidermis. All these oily leaves are distinguishable by their lively odour, which is particularly developed when we bruise them in the hands, and by the manner in which the vegetables which bear them quickly change the air of the atmosphere. Amongst the species of plants with odoriferous leaves, are especially enumerated balm, the mints, especially pepper-mint, phlomis, origanum, rosemary, and many other labiated plants. The odorous leaves of the umbelliferous plants, and especially of parsley, chervil, fennel, and angelica, also afford volatile oil. For the rest the chemical character of
this

this family is to contain volatile oil in every part. The leaves of the composite plants, such especially as wormwood, and camomile, afford much of it; hypericum and rue are of the same class.

6. There are fewer flowers capable of furnishing it. We may however distinguish the florets, and semi-florets of the camomile, as well as of several syngenesian plants, the petals of the lemon and orange trees, in which it is seen in transparent cavities. Many flowers contain it in their calixes, such as the rose, the clove, lavender, thyme, and a great number of labiated plants; sometimes even we can observe the vesicles that serve as reservoirs for it, like small tubercles, or ridges, or parts more transparent than the rest. In general we observe that the oleiferous perianthuses are either fleshy like those of the rose, or squarrose and ligneous, like those of the labiated plants.

7. Volatile oil is sometimes fixed in the fruits, and especially in their teguments. Vanilla, cardamoms, cubebs, pepper, the berries of the juniper, are of the first order. Lemons, oranges, citrons, bergamots, and all the fruits of the genus *citrus*, contain it in their external coloured skin, and in small cells, excavated in their zest, which are easily perceived on the outside of these fruits, and which appear in the form of small cavities dispersed over its surface: here the quantity of this oil is sufficiently considerable, and the reservoirs
which

which contain it are sufficiently full for it to be extracted by simple pressure, as is proved even by the play of children when they squeeze orange-peel close to the flame of the candle, in which the volatile oil affords a flash of fire and very white sparks, as it passes through it.

8. Lastly, there are a multitude of seeds from which the volatile oil is extracted in considerable abundance ; but it is not contained in their interior, as I have already remarked ; Nature has even taken many precautions in order to remove it from the embryo lodged between the cotyledons. On the outside of these there is a tunic, frequently horn-like, sometimes double, in the duplicature of which the particles of volatile oil are lodged ; so that being situated on the outside of this hard and impenetrable integument, it cannot pass through and reach the interior part. This admirable structure is especially observed in the seeds of a great number of the umbelliferous plants, whose ridgy furrowed, tuberculated surface is placed beneath these appendages of small drops of volatile oil. What has been said of the nutmeg, which contains volatile oil in its interior substance, must be understood only of a particular substance which is not the pulp of the cotyledons itself, but a kind of perisperma, which has no communication with the embryo.

9. The quantity of volatile oil varies greatly in the parts of vegetables that contain it, according to the age and the soils which have produced them. Some plants yield more of this
oil

oil when they are fresh; others, which are fewer in number, afford more of it when they are dry. We may see in the Elements of Pharmacy of Baume, an useful notice concerning the preparations of this matter extracted from the principal plants in common use, in different states and in different years.

B. *Extraction.*

10. THERE are two general processes for obtaining volatile oil. When this principle is sufficiently abundant, fluid, and contained in vesicles, almost insulated and pure, so as to be capable of being separated from them by mechanical means, simple expression is then employed. It is in this manner that the volatile oil is extracted from the lemon, the citron, the bergamot and the orange; it is well known that by pressing the fresh peels of these fruits we cause this oil to shoot out in the liquid form. In the southern departments of France, and in Italy, these fresh peels are rasped, the oily cells are lacerated, the paste formed by the parenchyma impregnated with oil is pressed upon inclined plates of glass, the oil collects upon them in drops which unite, and run towards the bottom where they are collected; they are suffered to deposit a fine sediment by being kept at rest in close vessels, and thus are obtained what perfumers call essences extracted without heat.

11. Most of the oleophorous plants do not admit of this treatment, because they do not contain

contain the volatile oil so detached, so distributed, so fluid, and so abundant: all these and their parts which are dry are treated by distillation. After they have been macerated for some hours in water; they are put with the water into a copper alembic, which is filled about two thirds; a capital of tin provided with a refrigeratory is added, and luted with sized paper to the cucurbit. The fire is urged to ebullition, after cold water has been put into the refrigeratory; a large quantity of the vapour of odorous water rises charged with volatile oil, which it actually contains in solution, and accompanied with the portion of volatile oil which it cannot dissolve on account of its abundance; both these products are received into a vessel of glass of a particular form, which is called a Florentine receiver, because it was first used at Florence. It is a conical vessel having a tube a little above its bottom, the upper extremity of which reaches only a little below the aperture of the receiver, and which, being curved at this place towards the base, suffers the more abundant portion of water to run off, and permits the oil to collect in the upper part of the receiver; formerly a worm was employed in the distillation of the volatile oils, but it has been laid aside, because it was perceived that a portion was lost, which attached itself to the sides of the metallic tube.

12. The water which passes with the oil is white, turbid, and as it were milky, because it contains a small quantity of oil suspended; but this

this liquor gradually clarifies, by depositing this oil, which rises to its surface and unites with that which passes immediately in drops. When this water has become clear, it is still charged with the odour of the plant, and it was formerly thought to be impregnated with a particular principle of the vegetable which Boerhaave called *Spiritus Rector*, and was designated by the name of *Aroma* in the methodical nomenclature; concerning the pretended existence of which I shall show that the chemists have committed a great error. This odorous water, which accompanies the volatile oil in its distillation, is nothing but a real solution of volatile oil in the water as I shall soon demonstrate. As a first proof I here mention the property which it has long been admitted to possess, of augmenting the quantity of oil that can be obtained by the distillation of a plant, when we distil it dry and scarcely odorous, with the aromatic water obtained from the same plant: this is always carefully practised in laboratories that are managed with proper care and attention.

13. Some different practices are followed in the distillation of the volatile oils, according to the dry, solid, or more or less hard nature, and according to the proportion of this principle which exists in the vegetable substance. The roots, the woods, the barks, the fruits, the dried plants, are macerated for a longer or shorter space of time in water, after they have
been

been cut, chopped, rasped or pounded. This maceration continues from some hours to some days, according to the solidity or the dryness of the vegetable matter. In order to raise the mixture of water and plants to a higher temperature, and to cause a greater quantity of volatile oil to come over, chemists have recommended a certain dose of muriate of soda to be added, which by giving greater density to the water, causes it to assume a higher temperature previous to its volatilization. The fresh plants in full vegetation are distilled with less water, and do not require to be previously macerated, nor do they demand so high a temperature in order to give out their volatile oil.

14. A process was formerly employed in the laboratories of pharmacy and perfumery, which has long since been laid aside on account of its imperfection and the bad product which it afforded. The vegetable matter, generally dry, especially the clove, was bruised and placed upon a piece of linen extended over the surface of a conical glass almost full of water; upon this linen and above the vegetable matter which it supported, a plate of copper containing ignited coals was placed; the caloric disengaged from these coals penetrating the vegetable substance, fused and separated the oil which passed through the linen, and fell into the glass, where it was collected at the surface of the water. This operation was termed *distillation per descensum*, on account of the direction which the fire placed above gave to the vapour; but it afforded a
brown

brown and partly burned oil, mixed with that which the strongly torrefied vegetable matter yielded, and with coal; it had besides the inconvenience of causing a loss of the greater part of the volatile oil, which escaped between the linen and the bottom of the plate of copper.

15. As most of the volatile oils are intended for perfumery under the name of essences, and appropriated to the preparation of different fragrant matters, I must here subjoin a fourth process which is not generally ranked in this order of chemical facts, because it has been considered as belonging to the history of the aroma, the particular existence of which I do not admit, for reasons which I shall soon explain. There are some plants or flowers of an extremely pleasant and agreeable odour, from which no volatile oil can be obtained by distillation, because this principle is so delicate in them, so much attenuated, and so easy to be decomposed, that the temperature requisite for disengaging it destroys it, alters it, and renders it fetid: such are the tuberose, the narcissus, the jonquil, the lily of the valley, the hyacinth and most of the so highly fragrant flowers of the liliaceous tribe. Such are also in other families of vegetables, the reseda, the turnsole and some others. A method has been contrived for collecting, fixing, and dissolving this very fugacious and decomposable odorant principle, by inclosing these flowers in cotton impregnated with a fixed inodorous oil, and suffering them to macerate for some time at a mild temperature.

perature. The oil of ben is taken for this operation; alternate layers of cotton impregnated with it, and of flowers are placed over a water-bath; the last of the layers of flowers is covered with a thick layer of the oiled cotton; a tin lid is closed and well luted on; the vessel is then plunged into a water-bath, the water of which is kept at thirty degrees of heat and upwards; here it is left for some hours, or even some days; it is then cooled, after which the layers of cotton are carefully taken out, and pressed; the oil which flows out is charged with the odorous principle of the flowers, and forms a kind of artificial essence; and it is so true that it is to a volatile oil that this odour is owing, that by afterwards treating the perfumed oils with alcohol, we take from them all this odour, and in that manner prepare what were formerly termed spirituous essential waters, or spirituous aromatic waters.

C. Physical Properties.

16. THOUGH volatile oil, to whatever plant it may belong, and however varied it may be in its properties, nevertheless always presents some that are sufficiently distinct and sufficiently marked to be capable of being considered as characteristic of this genus of immediate materials; though we may particularly enumerate in this order their fragrance and their volatility, yet these properties have such a number of differences that it is impossible to describe

describe them in a general manner, and it becomes indispensably necessary to take a survey of the principal varieties which they present, in order to obtain a competent notion of the whole genus.

17. I shall begin with their odour. The utmost stretch of the imagination cannot comprehend the astonishing multiplicity of varieties and of differences that belong to this first character. Not only each plant and every oil has its peculiar character, but it also varies in each of these products, by shades which the organ of smell can alone appreciate, according to a multitude of circumstances, the influence of which it is impossible to point out though we can easily recognize their existence. What is of the greatest importance to be well known in this respect, is that there does not exist, as has hitherto been believed a particular principle independent of the oil itself, which was formerly considered as the aroma or *Spiritus Rector*, which was said to be disengaged from the volatile oil: it is the volatile oil intirely reduced into vapour, and acting in its totality upon the olfactory nerves.

18. The consistence of volatile oils varies, but much less than their odour. There are four principal kinds of consistence in these oils; some are fluid in appearance, like water or those of lavender, of rue, of lemons, of bergamot, and of citron; this is especially observed in the oils obtained by expression. Some are thick, and viscid, as are in general those of the woods, the roots, the barks and the fruits of India and America.

America. Others congeal and assume a granulated or solid consistence at temperatures more or less low, such as those of aniseed, fennel, parsley, and balm; some of the latter are always concrete, like that of the rose, which has the consistence of a butter or fat. Lastly, several are capable of crystallizing, and depositing in the midst of the portion that has remained liquid, transparent polyhedra, more or less yellow, which are nothing else than pure oil; it appears, however, that this latter effect which takes place only in the course of time, and has been observed especially in the oils of rosemary, and of lavender, depends upon a commencement of oxidation, as Citizen Vauquelin had suspected. Sometimes these oily crystals have been confounded with camphor, which is easy to be distinguished from them, as I intend to show.

19. It must also be admitted that a great difference obtains in the colour of the volatile oils. There are some which are colourless or have only a slight lemon-colour, like that of aniseed, and most of those that are extracted without the action of fire from the skins of fruits. Most are of a more or less marked yellow, such as that of the officinal lavender, that of the greater lavender, which is called oil of spike, *lavendula spica*, and a great number of others; some are of a deep yellow, red or brown colour, as the oils of cinnamon, of cloves, of Rhodium, &c.; several are blue, that of camomile, green, like that of parsley, of a greenish blue,

blue, like that of hypericum; some are obtained blue at the moment of their distillation, but afterwards become red by lapse of time, as is observed in the oil distilled from galbanum, &c. In general the yellowish and reddish are the two predominant colours in the volatile oils, and it is always at one or other of these tinges that they arrive and remain.

20. The taste of the volatile oils is almost constantly acrid, pungent, hot, and even burning; some, however, have only a very feeble taste. Frequently those vegetable substances that are very acrid and bitter, do not yield an oil that has this property, as is the case with pepper and with worm-wood. When we place a single drop of volatile oil upon the tongue, it produces upon it the sensation of a very violent burning and irritation. This sensation frequently even propagates and extends itself into the throat, the oesophagus, and as far as the stomach, by an impression of heat and acrimony, which excites with delicate and nervous persons, spasms, borborygmi, eructations, nausea, weakness, and sickness. Frequently this scene, which is entirely owing to the nervous action, terminates in evacuations. Accordingly the physicians, who rank this matter amongst the almost caustic and acrid substances, when it acts in the mass, have considered it, when prescribed only in a very small proportion, and extended in a voluminous vehicle, as a stimulant, and more or less powerfully irritating. Its effect is speedily propagated to organs far remote from the place

to which the volatile oil is applied : in this manner it quickly imparts to the urine a strong smell, which is frequently agreeable, and resembles that of the iris or violets. It is by a similar principle that asparagus appears to communicate to it an insupportable fetor.

21. In general, the volatile oil has a specific gravity inferior to that of water, and as is well known, swims upon the surface of this liquid. However, those of the clove, of cinnamon, and of saffrafrs sink in water ; but it is not to be concluded from hence, that the oils of exotic plants, those of India especially, are generally heavier than water, since those of mace, of nutmegs, of pepper, of cubebs, of cardamom, are lighter than this liquid. In general the specific gravity of the volatile oils that are lighter than water is to that of this liquid as 8697, 8938, 9910 to 10000. That of those which are heavier on the other hand, : : 10363 or 10439 : 10000.

22. To this enunciation of characters, or physical properties, we must subjoin that of the adulterations or sophistications which are too frequently practised upon these oils ; it is almost always with the fixed inodorous oils or with oil of turpentine, the most common and the cheapest of these substances that the more costly volatile oils are diluted and their quantity increased. By rubbing a piece of fine paper which quickly becomes impregnated with it, we distinguish a volatile oil adulterated with a fixed oil, by the circumstance that when the portion
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of the first has been volatilized, there remains upon the paper an oily spot, formed by the fixed oil, which is not volatilized in the same manner. As to those that are mixed with oil of turpentine, they are distinguished by the very characteristic odour of the latter, which remains for some time after the volatilization of the other. Mere friction in the hands is frequently sufficient to distinguish both these sophistications by the smell. It is more difficult to distinguish the mixtures of the volatile oils that resemble one another in their smell, consistence and colour; but these are more rare and less fraudulent. When they are mixed with alcohol, we may easily discover this fraud by throwing them into water, which produces a very abundant milk-white precipitate.

D. Chemical Properties.

23. AFTER what has been shown in the two preceding articles concerning the chemical properties of the fixed oils, it is only necessary to compare the volatile oils with the former, and to insist upon the differences that subsist between these two genera of bodies. It is evident, that the first difference which characterizes them, and which is expressed by their name, is that they must be infinitely more difficult to be decomposed by the action of the fire than the fixed oils. They are reduced so quickly, and so easily into vapour, that it is almost impossible to effect their decomposition

in this manner. However by distilling them very slowly with a gentle heat, after having fixed them to a certain degree by means of very fine sand or alumine, they afford water, carbonated hydrogen gas, carbonic acid gas, a portion of oil a little thickened, and they leave a coaly mark. By repeating this operation, the volatile oil is at length decomposed, though very slowly, and with great difficulty.

24. They are much more combustible, they inflame in the cold by the mere contact of a body in ignition, or by the electric spark; they diffuse, whilst burning, an abundant smoke, and yield much soot; their flame is very strong and very white; the heat which they disengage very abundant, and they require more oxygen for their combustion than the fixed oils, and afford more water amongst the products of their combustion. This manifestly proceeds from the large portion of hydrogen which they contain, and from the smaller quantity of their carbon. On account of their greater combustibility, the oil of lavender, or spike, is used for the purpose of lighting lamps for illuminations with greater dispatch, by first impregnating their wicks with this oil.

25. When exposed to the cold air, they undergo another kind of alteration. Most of them become coloured and thickened, they all emit a strong odour; they vitiate the air, and quickly render it deleterious to animals, as is proved by the paintings in which they are employed; they emit hydrogen which forms
water,

water, of which we frequently find drops more or less perceptible at their surface, when they are kept in vessels not properly closed. Some of them crystallize; most of them pass into the resinous state, and then lose the greatest part of their odour; which manifestly depends upon the joint effect of the loss of a portion of their hydrogen, and the augmentation of their carbon.

26. They combine sensibly and easily with water. It is sufficient to agitate them in this liquid, in order to dissolve them. The fluid then contracts a strong smell, and a slight acrid taste; it is in this manner that I prepare the fragrant aromatic waters, which are nothing more than solutions of volatile oil in water, prepared by the action of fire, and distillation.

27. They dissolve phosphorous and sulphur. The first of these solutions, which is luminous in the dark, is very fetid, and affords phosphorated hydrogen gas by the action of fire, the second, which is very much coloured, and known by the name of *balsam of sulphur* in pharmacy, a name to which that of the oil with which it is prepared is added, as *terebinthinated, anisated, &c.* affords much sulphurated hydrogen gas by the action of heat. They do not act upon the metals, nor do they combine with their oxides like the fixed oils. In general they are less disposed than these to form oily oxides, and when treated with oxygenated matter, whatever these matters may be, they tend rather

rather to be decomposed, and to suffer their hydrogen and carbon to become insulated.

28. This is the reason of the difference of the action which the acids exert upon the volatile oils, from that which they exert upon the fixed oils. In general the former are much more decomposable and alterable by these bodies. The concentrated sulphuric acid renders them brown and thick, by disengaging part of their hydrogen with effervescence and heat; it converts a portion of them into water. What remains of the volatile oil after this action, is neither a resin, nor a bitumen, as has been believed; it is really the volatile oil reduced to coal, in part decomposed, and containing an acid. The nitric acid, charged with nitrous gas, inflames them immediately, converts a large part of them into water and carbonic acid, but leaves a voluminous and light coal; the same acids, diluted with water, turn these oils white or yellow, and thicken them, but do not reduce them to the real saponaceous state, as has been pretended. This is only a slow decomposition, which tends to convert them into vegetable acids. The muriatic acid alters them but very little. The oxygenated muriatic acid whitens them, renders them partly concrete, or thickens them, and brings them nearer than the preceding to the resinous state.

29. The alkalis do not dissolve them but with much difficulty: hence the very long discussions amongst the chemists concerning
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the soap proposed by the alchemist Starkey. The small quantity of soap obtained by triturating concentrated caustic alkaline leys, with the volatile oils, and leaving them for some time together, is termed *savonule* in the methodical nomenclature, in order to indicate, that it is in fact a combination very slightly, or very little saponaceous. This weak combination between these matters, evidently depends upon the little tendency which a volatile oil has to absorb oxygen without being decomposed by it, or to form an oily oxide.

30. The salts exert no sensible action upon the volatile oils. The nitrates burn them with the assistance of heat. The super-oxygenated muriate of pot-ash inflames, and destroys them by percussion. The metallic salts and solutions are frequently decomposed by the volatile oils, especially when they are left for a long time in contact with these mixed combustible bodies. Thus a solution of gold, agitated with a volatile oil, and kept for a long time with it, precipitates grains or plates of gold: the oil acquires, in this case, the property of separating in the crystalline, solid, and regular form, as has been observed by Citizen Vauquelin.

31. Lastly, volatile oil unites more or less easily with the different materials of vegetables that have already been examined. Mucilage, sugar, and even fecula, with the aid of a little heat, render them either soluble or capable of remaining for a long time suspended in water. It is in this manner that we may communicate to this liquid, or
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to several other bodies, the aromatic part of fruits with volatile oil, such as the citron, the orange, &c. the peel is rubbed with sugar, which absorbs a portion of oil; and afterwards dissolve this sugar in water: this is what is named *oleo*, or *oleosaccharum*. The volatile oils are very easily united, either with the fixed oils by simple agitation and mere mixture, or with the waxes and vegetable butters, by means of a gentle heat. The latter fix them in some measure, and thus form the unguents, or the fragrant ointments of the ancients. Nature presents, ready formed, this union of an oily and butyraceous juice with a volatile oil, in the butter of nutmegs and in several other vegetables.

E. *Species.*

32. ALL that has been said concerning the principal differences of the volatile oils, especially as to their situation, of their extraction, and of their physical properties, might in fact be sufficient to obviate the necessity of distinguishing species in this vegetable principle, and even to establish a sufficiently marked distinction amongst them. I shall, therefore, content myself with presenting a concise sketch of the method which may be followed in order to divide the volatile oils into species, at the same time remarking, that I cannot attend to the object of treating simply of the numerous series of

of oils, which are employed in the arts, but shall merely refer them in general to a certain number of principal species.

33. On comparing with each other the very numerous volatile oils, which are extracted from plants for the purposes of pharmacy or perfumery, I divide them into six principal genera, according to their sensible characters, their chemical properties, or their mixtures, and I designate these six genera by the denominations of *fugacious* oils, *light* oils, *viscid* oils, *concrete* oils, *ceraceous* oils, and *camphorated* oils.

34. I term those fugacious oils, which cannot be collected either by distillation, or by expression; which cannot be obtained except by absorbing them from the vegetables which contain them, and fixing them by means of fat oils. The principal species of this kind, which have hitherto been confounded with the spiritus rectors, or pretended aromas, are those of the lily, of the tuberose, the narcissus, of the hyacinth, of the convallaria, of the jasmine, of the rose, and of the heliotrope.

35. The light oils of the second genus are those which are very liquid, almost colourless, extracted by the mere expression of the cortices in which they are inclosed in very visible vesicles. The best known species are the essences of lemon, of orange, of citron, of bergamot, &c. It is to be observed, that these are capable of passing into the two following states, with the assistance of time and loss of hydrogen.

36. In the third genus I place the viscid or thick volatile oils, generally of a brown colour. The preceding, when kept for a long time, arrive at this state. This genus comprehends the oils of mace, of cardamoms, of pepper, and especially the oils that are heavier than water, of saffra, of cloves, and of cinnamon.

37. To the fourth genus I refer the volatile oils, obtained like the preceding, by the action of fire and distillation, but which assume a concrete or crystalline form, either by cooling, or by a slow evaporation and crystallization. The principal species of the first are, the oil of parsley, of fennel, of aniseed, of balm, of rose, to the second belong the oil of thyme, of marjoram, of mint, and undoubtedly a much greater number susceptible of crystallization.

38. The fifth genus is formed by the volatile waxy oils which nature presents, and which art extracts by pressure, and their previous softening by means of fire, in the concrete state, united with butyraceous, or waxy oily matters. Hitherto, we know only the oil of nutmegs of this genus, but there undoubtedly exist many others in nature.

39. Lastly, I appropriate the sixth genus of volatile oils to those which I term camphorated, because they naturally hold in solution the volatile and inflammable substance, which shall be examined in the subsequent article, under the name of camphor. The oils of rosemary, of sage, of lavender, of matricaria, of marjoram,
of

of pulsatilla, of the roots of zedoary, of valerian, &c. belong especially to this genus.

These distinctions, however, will be rectified in proportion as the observations upon these oils shall become more exact and more numerous.

F. Uses.

40. It has been seen, by all the preceding details, that the volatile oils are useful for a great number of purposes. Besides the medicinal properties which characterize them, and which cause them to be employed in many cases as very active and very valuable remedies: besides their very multiplied effects, and their frequent use in the form of aromatic waters; besides their application as stimulants, antiseptics, and external cathartics, they form the principal ingredient of perfumes. They constitute all the odours that were formerly called *spiritus rector*s or perfumes; it is not only in their primitive state of essences that they are employed in perfumery; they are combined for that purpose with fixed oils, with mucilages, with fecula, with alcohol, with vinegar, with fats. They are added to the powders, and the kinds of plants that are used for filling the perfuming bags, the *pots-pourris*. Their forms and modifications are varied in all possible ways.

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They also enter into the composition of some fragrant substances for burning, or of aromatic pastils.

They are mixed with a great number of liquors, in order to render them aromatic and agreeable, especially the liquors used at table.

They are also employed as combustible bodies in some circumstances.

They are used for preserving dead bodies, and form part of the materials used in embalming.

Lastly, They are sometimes mixed with resins and gum-resins in the preparation of colours and pigments.

END OF THE SEVENTH VOLUME.

